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ABSTRACT

Research in training subjects to comprehend compressed speech has led to deeper studies of basic listening skills. The connected discourse is produced by a technique which deletes segments of the speech record and joins the remainder together without pitch distortion. The two problems dealt with were the sources of individual differences in the ability to understand time-compressed speech and the temporal characteristics of language which facilitate or impair listening comprehension. By reducing the amount of time available for the listener to process speech, the nature of listening priorities emerges. The insertion of temporal spacing at linguistically strategic locations have enabled the experimentors to determine whether they are behaviorally strategic. The identification of behaviorally strategic locations has, in turn, enabled them to further understand the nature of those activities which are necessary for processing speech and to what aspect of speech they are directed. The correlates and predictors of success at these tasks further enrich the picture of what underlies successful listening. (MM)

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Behavioral Sciences
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SUMMARY

The main goal of this project was to examine listening behavior of college age students to time-compressed speech. The latter is produced by a technique which deletes minute segments of the speech record and abuts the remainder together without pitch distortion. Earlier research has shown that comprehension is unaffected when the rate of presentation is about doubled.

This study dealt primarily with two problems: (1) the sources of individual differences in the ability to understand time-compressed speech, and (2) the temporal characteristics of language which facilitate or impair comprehension. Ancillary studies compared several measures of listening comprehension and various ways of preparing and presenting compressed speech material.

Scores on a battery of predictor tests were correlated with performance on multiple-choice comprehension tests, based on texts presented at several rates. The results of a multiple-regression analysis indicated that correlations between predictors and criteria decreased as rate of compression increased. The exception to this trend were tests measuring the ability to evaluate semantic relations, one component of the Guilford structure-of-intellect model, which were more strongly correlated with comprehension test performance as compression rate increased.

Another aspect of the research was concerned with the effect on listening comprehension when temporal spaces were selectively inserted at major syntactic junctures within sentences. It was found that individual sentences segmented at phrase boundaries were more accurately recalled when the sentences were highly compressed than were either non-spaced sentences or sentences segmented at loci which violated phrase structure. Results of temporal spacing at structural junctures were confirmed with connected prose passages, using cloze-type measures of comprehension.

Finally, the ability to evaluate semantic relations was found to interact with temporal spacing: listeners who were above average in this ability were assisted by structural segmentation to a greater degree than were listeners below average in the ability, especially at high rates of compression.

The effect of temporal spacing was interpreted in terms of its organizing function for memory, and the ability to evaluate semantic relations was discussed in the light of Quillian's "pathfinding" theory of text understanding.

The overall findings suggest that the approach which combines temporal with linguistic variables in the examination of basic listening behavior holds much promise. Recommendations are made that this approach be extended to more complex material. The potential value of an enriched understanding of basic listening skills is described.

INTRODUCTION

Introduction

This is the report of the third in a series of projects sponsored by the United States Office of Education to investigate time-compressed speech as a potential medium for education and as a technique for enhancing our basic understanding of listening behavior. The first two projects were directed toward the possibility of training comprehension of connected discourse at greater than nomal rates of presentation and did so by the examination of a large number of variables in speech presentation and in material content relevant to the educational setting. The results of those studies established conclusively that judicious exposure to time compressed speech can relatively quickly be used to achieve normal comprehension by student listeners at two to two-and-one-half times normal speed of college level materials. While that research was successful in its goals, it raised, as often is the case, a number of fundamental questions about the nature of listening behavior, not only to time compressed, but to normally presented speech as well. The research conducted in this project has been directed to three of these fundamental questions: (1) What are the underlying listener abilities which make possible the processing of speech at high rates of presentation? (2) To what aspects of speech are they directed? and (3) What techniques of presentation can optimize the match between what the listener must accomplish and the arrangement of speech that most effectively permits him to accomplish it.

The six progress reports submitted to date cover the bulk of the research conducted in detail. This report will summarize and integrate the overall findings of this research effort and place it in the setting of the theoretical consequences of these research results.

Time- compressed speech is produced by a technique which permits the reduction in duration of tape recorded speech by systematic deletion of minute (20 to 40 milliseconds) segments of the speech record. What is left of the speech is abutted together so that no gap appears between speech samples nor are they distorted with respect to pitch. Given the current state of the art, the most practical means of achieving time compression is by electro-mechanical devices which delete segments in a pre-set time pattern without respect to the content of the tape. The net result is a faster rate of speech presentation which, as earlier research has disclosed, remains intelligible to about double speed for college level material without prior exposure. (By doubling instead of deleting the discard segments, speech can be expanded or slowed.) The implications of intelligible speech presented far beyond the normal speaking range, are just now beginning to be felt. Potentially, time compressed speech may be used in at least five different major ways:

(I) as a means of presenting information at a faster rate, as in the educational or any informational setting; (II) as a means of training listening behavior in specialized setting where messages come quickly or more than one arrive at a time; (III) as a means of identifying aptitudes, or identifying deficiencies in listening skills; (IV) as a means of diagnosing individual characteristics related to the content of the presentation; and (V) as a basic research tool which permits the highly important variable of time, to be manipulated without major loss of intelligibility. While our research continues to focus on college students as the likely target of time-compressed presentations for educational purposes, it does so by investigating basic listening attributes in Phase I of the project. This is accomplished by examining the correlates and predictors of comprehension and recall in three successive major studies. Phase II concentrates on stimulus manipulation, and it is in this effort that significant findings with regard to temporal spacing are reported. The Phase III research which became closely integrated with II, involved the manipulation of listener task and the measurement of comprehension in such a way that further light might be shed on the nature of activities which take place at the sentence level.

Overall, a unique approach to the investigation of basic listening behavior has been taken; one which combines the manipulation of temporal variable in speech both by time compression and temporal spacing, with the linguistic characteristics of the oral language.

By reducing the amount of time available for the listener to process speech, the nature of listening priorities emerge. The insertion of temporal spacing at linguistically strategic locations have enabled us to determine whether they are behaviorally strategic. The identification of behaviorally strategic locations has, in turn, enabled us to further understand the nature of those activities which are necessary for processing speech and to what aspect of speech they are directed. The correlates and predictors of success at these tasks further enrich the picture of what underlies successful listening.

Since this two year project consists of a series of studies a journal style is used to report them singly, although they are joined together in the discussions of each section.

PART I

COMPRESSED SPEECH: CORRELATES OF LISTENING ABILITY

Studies at the American Institutes for Research have suggested that listening comprehension at normal speech rate does not necessarily correlate with comprehension at high rates of compression. Furthermore, individual differences in understanding compressed speech become more evident as the rate of compression is increased. These facts suggest that the comprehension of a highly compressed speech signal may be dependent upon certain skills which are less discernibly implicated at normal or near-normal speech rates. The possibility that some special competence is needed to comprehend highly compressed speech is consistent with conclusions drawn from studies of individual differences in perceptual motor skills which have demonstrated changes, as a task becomes more difficult, in the relative contribution which specific skills make to the performance of the task (Fleishman, 1957).

The purpose of the study described in this report was to specify sources of individual variation in the comprehension of compressed speech. Accordingly, we attempted, first, to identify some of the correlates of listening comprehension, both at normal and compressed speech rates; second, to inspect the correlation data for patterns of change associated with increases in the rate of compression; and, finally, to relate the results of the correlation study to current theories of higher cognitive processes and models of speech perception in order to form hypotheses about some of the implicit processes and mechanisms involved in listening. The study is an extension and refinement of previous work (Friedman, Orr, and Norris, 1966; Orr and Friedman, 1967; Orr and Friedman, 1968; Orr, Friedman, and Williams, 1965).

METHOD

Subjects. Twenty-nine male and twenty-three female undergraduates, recruited from two universities in the Washington, D. C. area, were paid participants in the study. Thirty were freshmen and twenty-two, sophomores, and their mean age was 18 years 4 months. All were native speakers of English, with no gross hearing deficiencies. None had any prior experience in listening to compressed speech.

Procedure. Students were tested usually in small groups, but sometimes individually, during two or three hour sessions spread over a period of a month. The order in which particular tests were administered to students was determined by the exigencies of scheduling, and no attempt was made either to maintain a uniform sequence for all participants or to counterbalance the order of administration.

The diversity of the test battery seemed likely to preclude any significant order effects.

Materials. On the basis of results obtained from an earlier pilot study, 10 tests were investigated as possible predictors of listening comprehension:

1. The vocabulary section of the Nelson Denny Reading Test (designated ND).

2. An estimate of silent reading rate, as determined from performance on the Nelson Denny Reading Test.

3. The Space Relations subtest of the Differential Aptitude Test (DAT) battery, which measures the ability to imagine the way a flat pattern would look if it were folded to form a three dimensional construction.

4. The Sentences section of the DAT Language Usage subtest, which requires the subject to detect instances of incorrect grammar, punctuation, and word usage.

5. The Clerical Speed and Accuracy subtest of the DAT battery, which requires the subject to rapidly match various alphabetic and numeric combinations.

6. The verbal section of the Lorge-Thorndike Intelligence Test.

7. The Brown Carlsen Listening Comprehension Test.

8. The Phonetic Script section of the Modern Language Aptitude Test (MLAT), which requires subjects to discriminate sequences of speech sounds and learn to associate them with orthographic symbols.

9. The Spelling Clues subtest of the MLAT, which measures a student's knowledge of English vocabulary, and to some extent taps the same sound-symbol association ability measured by the Phonetic Script section.

10. Best Trend Name Test, which requires subjects to infer the semantic relationship among a set of words. For example, the subject is given the words "horse - push cart - bicycle - car" and is asked to decide whether the relationship among the four terms is best described as one of "speed," "time," or "size." The correct answer is "time" since the sequence describes an order of historical development; horses were the earliest means of transportation, cars the most recent. The ability measured by this test is the "evaluation of semantic

relations" in the Guilford structure-of-intellect model (Hoepfner, Nihira, and Guilford, 1966). This model is a three dimensional classification system for describing the contents, operations, and products of human intellectual abilities. The model postulates the existence of 120 discrete intellectual abilities, of which the "evaluation of semantic relations" is one (Guilford, 1968).

The four criterion variables (here designated C_1 through C_4) were multiple choice comprehension tests based on the content of four excerpts from a history of seventeenth century England. The tests previously had been equated for level of difficulty and standardized on a college population. Subjects were tested for listening comprehension immediately after hearing a tape-recorded reading of each passage. The first excerpt was presented at a normal speaking rate of approximately 175 wpm. The remaining three passages were compressed on the Tempo-Regulator and presented, respectively, at 250, 325, and 450 wpm. All four passages and comprehension tests were presented in a single two hour session, but the scheduling of this block with respect to the ten predictor tests varied from subject to subject. Detailed information about the comprehension tests and their construction may be found in Orr and Friedman (1964).

RESULTS

Primary Study

A multiple regression analysis was performed on the test data to determine the extent to which a selection of these ten tests could efficiently predict listening comprehension at four rates of presentation. As a first step, a correlation matrix was constructed to show the intercorrelations among the ten tests and the four measures of comprehension. All entries in the matrix were examined to identify tests which were strongly correlated with one or more of the criterion measures, but weakly with one another. Tests were also sought which exhibited a pattern of increasing or decreasing correlations with comprehension measures, as rate of compression increased. Six of the tests seemed to merit further investigation. The Nelson Denny vocabulary score correlated relatively high with comprehension, at all four presentation rates. The Sentences section of the DAT Language Usage subtest was moderately related to comprehension only at normal speaking rate; as rate of compression increased, the correlation coefficients were found to decrease monotonically. Three tests, on the other hand, were more strongly related to comprehension at high rates of compression than at normal speaking rate: Phonetic Script, Space Relations, and Best Trend Name. Silent reading rate was found to correlate weakly with the criteria, but relatively strong with some of the possible predictors, thus suggesting that it might function as a "suppressant variable" in a multiple regression system.

The scores from these six tests were then subjected to a stepwise multiple regression analysis for each of the four rates of presentation. In Table 1 are summarized the results of the analyses. As a general observation, it can be seen that the multiple correlation coefficients tended to decrease in magnitude as rate of compression increased, but the corresponding F ratios were significant at each of the four rates.

As an alternative way to examine the data for a relationship between listening comprehension and performance on the six predictor tests, we used a two-factor experimental design with repeated measures on the second factor (Winer, 1962). A separate analysis was performed for each predictor. Subjects' scores on the multiple choice comprehension tests were categorized according to their performance on a given predictor test (i. e., whether they fell above or below the group mean for that test), and according to the rate of presentation (i. e., 175, 250, 325, and 450 wpm). Significant differences in listening comprehension were found between the high and low scorers on three of the six tests: Vocabulary ($F = 41.611$, $p<01$), Sentences ($F = 14.304$, $p < .01$), and Best Trend Name ($F = 4.902$, $p < .05$). However, the effectiveness of the Sentences subtest as a predictor of listening comprehension was found to decrease as rates of compression increased. This rate-related loss in effectiveness was reflected in a significant interaction observed between comprehension and Sentences test scores ($F = 3.041$, $p < .05$).

The results of the multiple regression study and analysis of variance identified the Nelson Denny vocabulary measure as the most efficient predictor of listening comprehension at all four rates of presentation. However, Table 1 shows that the beta weights for this variable became smaller as rate of compression increased, suggesting that the general language aptitude which appeared to be involved in comprehension at the normal rate of presentation was relatively less important at higher rates.[1]

---

[1] A similar loss of predictiveness was observed for the verbal section of the Lorge-Thorndike, but the decline associated with increasing rates of compression was even more accentuated than was the case with Nelson Denny vocabulary.

Table 1

Prediction of Listening Comprehension at Four Rates of Presentation (N=52)

		Predictors							Criteria			
		1	2	3	4	5	6		7	8	9	10
Mean		61.08	40.37	25.85	66.83	12.68	374.81		14.55	13.41	10.14	4.93
S.D.		16.92	12.31	3.53	18.30	3.88	121.32		4.92	6.24	6.57	3.64
		Intercorrelations							Beta-Weights			
Vocabulary (ND)	1	1.00	.51	.22	.15	.30	.54		.54	.53	.53	.44
Sentences (DAT)	2	.51	1.00	.31	.09	.24	.26		.30	.22	.19	.06
Phonetic Script (MLAT)	3	.22	.31	1.00	.17	.28	.16		-.14	-.09	.04	.03
Space Relations (DAT)	4	.15	.09	.17	1.00	.51	-.05		.16	.13	.16	.06
Best Trend Names	5	.30	.24	.28	.51	1.00	.18		-.10	.04	.07	.36
Reading Rate (ND)	6	.54	.26	.16	-.05	.17	1.00		-.06	-.12	-.26	-.17
						Multiple R			.76	.64	.61	.63
						F Ratio			10.09*	5.32*	4.32*	4.93*
		Validity Coefficients							b-Weights			
C-1 (175 wpm)	7	.67	.59	.09	.20	.32	.28	1	.16	.20	.20	.10
C-2 (250 wpm)	8	.58	.45	.10	.24	.22	.20	2	.15	.11	.10	.02
C-3 (325 wpm)	9	.50	.40	.12	.27	.19	.06	3	-.20	-.17	-.08	.03
C-4 (450 wpm)	10	.54	.28	.33	.34	.42	.18	4	.04	.04	-.06	.01
								5	-.13	.06	.01	.34
								6	-.00	-.01	-.01	-.01
						Intercept			.76	-2.13	-5.11	-6.10
						σ Estimate			3.42	5.08	5.57	3.00

*p<.01, df = 6 and 45

In contrast, the ability measured by the Best Trend Name Test was marginally involved in understanding material presented at normal or near-normal rates, and gained significance as a correlate of comprehension only at the 450 wpm rate, thus running counter to the trend. The pattern of increasing beta weights associated with this test singled out the underlying behavior as a source of individual variation in the comprehension of highly compressed speech.

To define the skill which the Best Trend Name Test measures, the intercorrelations among ten tests were factor analyzed by means of a principal axis solution. Three factors, yielding eigenvalues greater than 1.0, accounted for 70% of the common variance. The rotated factor matrix and list of ten variables is presented in Table 2. The first factor received appreciable loadings on three variables: the reading rate and vocabulary measures of the Nelson Denny Reading Test, and the Spelling Clues section of the Modern Language Aptitude Test. This configuration of variables clearly suggested that vocabulary knowledge was the dominant component. The third factor obtained a high loading only on one variable, the Phonetic Script section of the Modern Language Aptitude Test, indicating that this test is relatively independent of other measures of verbal ability and general academic aptitude.

It was Factor II, however, which was most interesting in terms of the present study. The Best Trend Name Test was one of the variables which defined this dimension, together with Space Relations and Clerical Speed and Accuracy. The common task which underlies these three tests is a rapid comparison of alternative responses to find one which is most similar to a stimulus. All tests involve some variant of matching-to-sample behavior, but the subject is not required to produce a response to match the stimulus, only to compare and choose among a set of responses which are already available. This ability to make rapid comparisons is the defining characteristic of the cognitive operation called "evaluation" in Guilford's structure-of-intellect model. It is a significant historical note that prior to Guilford's classification theory, the evaluative operation was variously termed perceptual speed, speed of judgment, and speed of association (Hoepfner, Nihira, and Guilford, 1966). Clearly, the rate of responding is an essential aspect of this ability. The Best Trend Name Test was not designed as a general measure of evaluative ability, however. It was constructed specifically to assess a person's ability to evaluate semantic relations, the meaningful connections between verbal "units." To perform well on this test, a person must be skilled in the cognitive matching operations necessary to infer the semantic connectedness implicit in a given set of verbal concepts.

Table 2

Rotated Factor Matrix Showing Factor Loadings
for 10 Predictor Variables on Three Dimensions

Variables/factors	I	II	III	h^2
Reading Rate (ND)	0.874	-0.018	0.098	0.777
Vocabulary (ND)	0.633	0.135	0.027	0.776
Space Relations (DAT)	-0.081	0.902	0.071	0.851
Clerical Speed and Accuracy (DAT)	0.160	0.850	-0.149	0.781
Lorge-Thorndike Intelligence Tests (Verbal)	0.448	0.259	-0.009	0.851
Best Trend Names	0.032	0.723	0.234	0.638
Phonetic Script (MLAT)	0.130	0.075	0.957	0.955
Spelling Clues (MLAT)	0.746	0.023	0.086	0.694
Sentences (DAT)	0.090	-0.015	0.230	0.805
Brown Carlsen Listening Comprehension Test	0.452	0.405	-0.041	0.654

Note: The Lorge-Thorndike Intelligence Test, the Sentences section of the DAT, and the Brown Carlsen Listening Comprehension Test defined the fourth dimension, but since its corresponding eigenvalue was less than 1.0, it was not included in this table.

Supplemental Study

In attempting to interpret these results, we recognized that a multiple choice test was not an uncontaminated measure of listening comprehension. General academic aptitude certainly affected a subject's level of performance. Even more unsettling in its implications for the present study was the fact that "responses to a multiple choice test sometimes reflect evaluative variance" (Brown, Guilford, and Hoepfner, 1966). Consequently, the ability to evaluate semantic relations may have contributed to a person's skill in answering multiple choice questions as much as it entered into listening skill itself. To avoid this type of confounding, we carried out a brief supplemental study using the same 52 subjects, but employing criterion measures different from the multiple choice tests. The stimulus materials were prepared originally by Miller and Isard (1963) for a study of sentence perception, and were of three types: meaningful, grammatical sentences; meaningless, grammatical sentences; and "random" word strings without meaning or grammatical order. These sentences and sentence-like strings were presented at the same rates of compression as the "C" passages, and the subject's task was to listen to each one and then transcribe it word-by-word as accurately as possible. Accuracy in this task was correlated with each of the six predictor variables listed in Table 1, and a step-wise multiple regression analysis was performed. Results were generally consistent with those already reported. At normal speech (about 175 wpm), the Best Trend Name Test was the least predictive of the six. But with compression, the test came to the fore as an effective predictor variable. We concluded, therefore, that the ability to evaluate semantic relations -- as measured by the Best Trend Name Test -- was a correlate of listening comprehension at compressed rates, and not merely an experimental artifact.

DISCUSSION

Merely to demonstrate a correlation between variables has little value unless it leads to a theoretical description of a mechanism of interaction, one amenable to independent test. The matching or comparison process, of which the evaluation of semantic relations is an example, has been suggested as a basic unit in the study of complex cognitive operations, similar to the way "the reflex serves as a unit of analysis within S-R theory" (Posner and Mitchell, 1967, p. 408). Matching may be conceived to be a basic unit of behavioral analysis because it is more or less directly measurable and because it has been incorporated as an important design feature in contemporary models of cognitive processing (e. g., Miller and Chomsky, 1963, pp. 483-488). In this concluding section of our report, the ability to evaluate semantic relations (as measured by the Best Trend Name Test) will be related to recent theoretical descriptions of listening behavior in an attempt to interpret our finding that skill in semantic matching is a correlate of listening comprehension at high rates of compression.

Neisser (1967) has outlined an "analysis-by-synthesis" model of speech perception which incorporates, as an important component, an evaluative operation similar to Bruner's (1951) "hypothesis testing" and Solley and Murphy's (1960) "trial and check" behavior. Listening, according to this model, is a sequential process. (See Figure 1.) The incoming flow of speech first passes through a "filter system" which segments the flow, extracts a few distinctive features, and tentatively recognizes some of the constituent elements or units. The filter system is not only feature sensitive, but context sensitive, and many of the tentative identifications are made on the basis of expectancies derived from contextual cues. Elements which pass through this filter system (the "preattentive phase") are the building blocks with which the listener then attempts to construct or synthesize an utterance internally to match the actual input. The constructive process is not aimlessly trial-and-error, but is guided by contextual information to synthesize the most probable identification first, the least probable last. Thus, context controls the order in which linguistic patterns are synthesized, and these patterns are successively constructed and compared with the actual input until a match is found. The occurrence of a match terminates the synthesis phase and the utterance is perceived.

Analysis-by-synthesis thus involves a "goodness of fit" test which compares the characteristics of the actual speech input with the characteristics of the tentative identification. It seems plausible to equate the ability to perform this comparison rapidly and accurately with the operation designated "evaluation of semantic relations" in the Guilford structure-of-intellect model, especially at the level of sentence perception and the understanding of connected discourse. The analysis-by-synthesis model specifies that the constructive process can occur on different levels, and yields synthetic units of varying length and complexity, depending on whether the perceptual task is to discriminate individual speech sounds, identify single words, or understand a sentence. As Neisser describes the process:

> Hearing an utterance, the listener constructs one of his own in an attempt to match it. Such matching may go on at "several levels" - that is, in terms of different segment sizes. If a single . . . word is presented, the listener's preliminary speech analysis may pick out a few distinctive

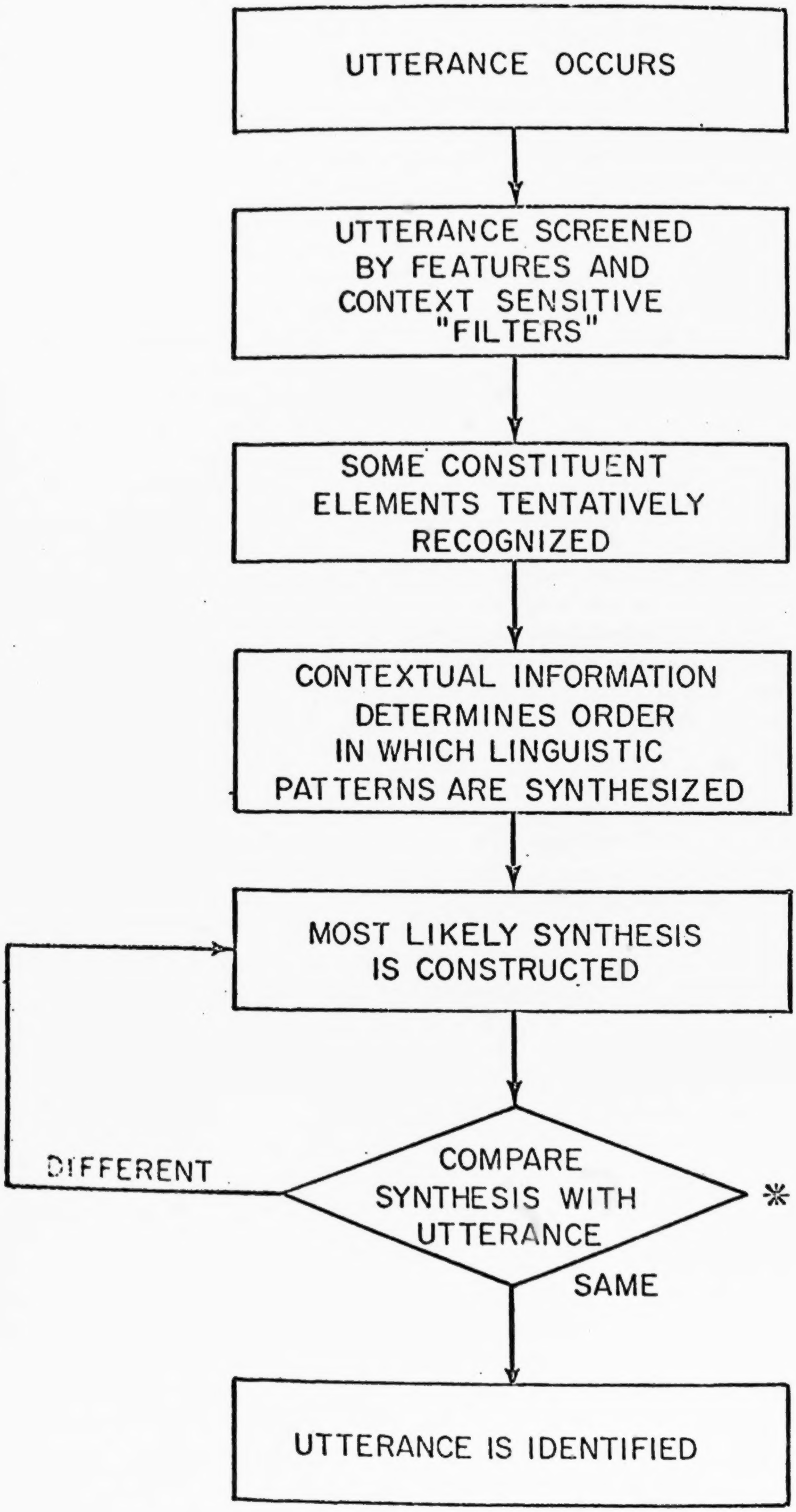
UTTERANCE OCCURS
UTTERANCE SCREENED BY FEATURES AND CONTEXT SENSITIVE "FILTERS"
SOME CONSTITUENT ELEMENTS TENTATIVELY RECOGNIZED
CONTEXTUAL INFORMATION DETERMINES ORDER IN WHICH LINGUISTIC PATTERNS ARE SYNTHESIZED
MOST LIKELY SYNTHESIS IS CONSTRUCTED
DIFFERENT
COMPARE SYNTHESIS WITH UTTERANCE
*
SAME
UTTERANCE IS IDENTIFIED

Fig. 1 Simplified flow diagram of "analysis by synthesis" model of speech perception. Asterisk identifies operation which may be related to the ability to evaluate semantic relations.

> features or syllables which suggest a tentative answer; various related words are then synthesized until one of them fits. If the stimulus is an entire sequence, a few words tentatively identified by the preliminary system may guide the synthesis of whole constituents as units, or even of the whole sentence (Neisser, 1967, p. 196).

Presumably, the type of operation necessary to evaluate a synthesis depends upon the level at which the synthesis takes place. Since the evaluation of semantic relations is defined as the comparison of the ways verbal concepts are meaningfully connected, we must assume that it functions at a very complex level in speech perception. The level at which evaluation occurs may itself have implications for the understanding of compressed speech. For the matching operation at higher levels of complexity appears to require more processing time than at lower, less complex levels (Posner and Mitchell, 1967). Conjunctionally, the technique of compression reduces the amount of processing time which is available to the listener.

By interpreting Guilford's concept of the evaluative operation as one step at one level in the analysis-by-synthesis sequence, we can perhaps offer an explanation for our finding that the Best Trend Name Test was a better predictor of comprehension at high rates of compression than it was at normal speech rate. When the speech signal is degraded in quality (as happens in the case of compression), the listener must repeatedly form, test, and reject hypotheses in search of adequate synthesis. Moreover, the need for greater perceptual processing of degraded information coincides with an increased rate of input. The result is that there is less time available to do more synthesizing. Under these conditions, the ability to perform the evaluative operation, with accuracy and rapidity, becomes a critical factor in the comprehension of compressed speech.

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PART II

EFFECT OF TEMPORAL SPACING ON THE RECALL OF TIME-COMPRESSED SENTENCES

The investigation of hesitation pauses and other temporal characteristics of spontaneous speech has stimulated theoretical thinking about the nature of encoding processes (e.g., Goldman-Eisler, 1968). In this study, the role of time in listening behavior was examined in an attempt to clarify our understanding of how sentences are remembered. The accuracy of sentence recall was related to the systematic manipulation of two temporal aspects of the speech event: (i) the insertion of temporal spaces within sentences, situating them either at strategic or non-strategic loci, and (ii) the control of the rate of presentation, by means of the technique of speech compression.

The compressed speech method offers an experimental tool for the study of sentence comprehension and recall which can be employed somewhat the way masking noise has been used. Both methods produce decrements in intelligibility and comprehension and the frequency and type of recall errors observed may yield clues about underlying behavior. The speech compression technique shortens the total duration of the speech event without distorting pitch by the periodic deletion of minute segments of the signal and the conjoining of the remaining portions. Most listeners are able to understand speech which has been moderately compressed, and can learn to comprehend materials presented at more rapid rates (Orr, Friedman, & Williams, 1965). But characteristically, the degree of listening comprehension decreases as rate of compression increases.

To explain this decrement, it has been suggested that listeners cannot both receive and remember a message simultaneously. The process of perceiving may interfere with the process of storing. Carroll (1967) has proposed that the message format be so designed that the two processes could occur at separate times.

> This would mean that pauses for storage and interpretation should be inserted into the flow of speeded speech. Thus, the speech would come out in relatively short "bursts" -- highly speeded short phrases that are punctuated with short pauses that are sufficiently long to allow the individual to store and assimilate the information just presented.

Similar speculations about the effect of temporal spacing are found in conference exchanges between Foulke and Bever (Kavanagh, 1968).

Some experimental grounding in support of this suggestion is provided by the repeated demonstrations that one reliable way to influence the accuracy of recall is to manipulate the internal temporal organization of the stimulus.

Aaronson and Markowitz (1967) investigated the effect of introducing temporal spaces between successive digits in sequences presented at accelerated rates by using the speech compression technique. As noted above, speech compression usually interferes with the comprehension of connected discourse (especially at high rates). But the investigators found that compressed, spaced sequences were actually recalled more accurately than were non-compressed, unspaced digit sequences. An analysis of errors indicated that temporal spacing tended to reduce the frequency of order confusions in serial recall, a finding that led the investigators to conclude that intervals between digits provided time for subjects to perceive and encode order information. However, the facilitative effect of temporal spacing in digit sequences does not generalize directly to natural language. Martin (1968b) found that placing spaces between every word in a sentence reduced the accuracy of its recall. Presumably, a listener-- in storing a sentence in short-term memory -- was constrained to remember a sentence word-by-word rather than in the more "natural" phrase groups. Thus, the effect of inserting spaces after every word was to induce a kind of temporal interference. The importance of surface phrase structure in the learning and remembering of natural language was further emphasized in a study by Wales (1966), who exposed subjects to sentences divided into three parts, either at the ends of syntactic constituents or at non-structural locations. Wales reported that subjects were more easily able to learn structurally segmented sentences than those divided non-structurally. Similarly, Anglin and Miller (1968) found that the rote memorization of connected prose passages was more rapid when the passages were presented in segments that conformed to the phrase structure of the sentences than when the segments violated that structure.

In the aggregate, these findings lend plausibility to an hypothesis that a listener needs time to understand and remember a sentence, and that the availability of time is more critical at some points within the sentence than at others. The specific purpose of this study was to attempt to attenuate the reduction in recall accuracy which results from speech compression by the selective insertion of temporal spaces in sentences and sentence-like strings.

METHOD

Subjects. The subjects were 48 college students (23 male, 25 female) who were paid for their participation in the experiment. All were native speakers of English and none reported hearing defects.

Materials. The experimental materials were short lexical strings, originally prepared by Miller and Isard (1963), for a study of sentence perception. The strings were of three types:

1. Meaningful, grammatical (hereafter designated "grammtical" strings). Example: "Colorless cellophane packages crackle loudly."

2. Meaningless, grammatical (or 'anomalous" strings). Example: "Colorless yellow ideas sleep furiously."

3. Meaningless, ungrammatical (designated "ungrammatical" strings). Example: "Sleep roses dangerously young colorless."

The strings were recorded for auditory presentation, and varied both in the type of temporal spacing within the strings, and the rate at which the strings were compressed.

There were three types of temporal spacing:

1. Temporal Spacing at Structural Junctures. Intervals of two seconds' duration were selectively introduced at major immediate constituent boundaries so that each string was segmented into three sections.

Examples: "The clock / was built / by a Swiss watch maker."
"Hunters / simplify motorists / across the hive."

2. Temporal Spacing at Non-Structural Loci. Two intervals, of two seconds' duration, were selectively introduced at loci within the strings which did not coincide with major immediate constituent boundaries.

Examples: "Union / leaders call sudden / strikes."
"The musicians explained the / worst oak / bill."

In recording the strings with non-structural spacing, care was taken to preserve natural intonation contours as much as possible.

3. No Spacing at all Within the Strings. Since the strings were all short (a mean length of six words, with a range of five to nine), each could be uttered during the span of a single breath-group (Lieberman, 1967).

Ungrammatical strings had no syntactic structure, and hence could not be structurally or non-structurally segmented. Each was read with a list intonation when recorded. Spaced versions were produced by dividing each ungrammatical string into three arbitrary segments of approximately equal length, as determined by counting syllables.

Procedure. The lexical strings were presented to subjects at normal speed (about 175 words per minute), and at three rates of compression: 1.4 times normal (250 wpm); 1.9 times normal (325 wpm); and 2.6 times normal (450 wpm). Compressed tapes were prepared using the Tempo-Regulator, and were presented to all subjects in order of increasing rates of compression. The duration of the temporal spaces did not vary with the degree of compression. All were approximately two seconds in length, regardless of the rate of presentation.

The subjects were randomly assigned to three groups of equal size (N = 16). Group I listened to structurally segmented grammatical and anomalous strings, and segmented ungrammatical strings. Five strings of each type were presented (in scrambled order) at each of the four rates of compression so that the listeners could not anticipate the type of string they were about to hear. Group II listened to non-structurally segmented grammatical and anomalous strings, and segmented ungrammatical strings, while Group III heard the three string types without any spacing. For these groups, as well, the three string types were presented in scrambled order.

Each subject was tested individually, and his task was to listen to the recorded strings, and after hearing each one, to repeat it aloud. Responses were tape-recorded and later transcribed. The scoring criterion was one used by Miller and Isard (1963): the number of complete strings that were repeated without any errors.

Comparisons Planned as Tests of Hypotheses. Prior to the conduct of the experiment, the following null hypotheses had been formulated, and appropriate tests devised.

1. There is no difference in the accuracy with which spaced and unspaced strings are recalled. If the hypothesis is accepted, the conclusion to be drawn is that spacing is not effective in attenuating the loss of recall accuracy due to time-compression. If rejected, we next planned to test the hypothesis that

2. There is no difference between strings which had been structurally or non-structurally spaced. If accepted, the conclusion is that recall is improved by temporal spacing itself; whether the resultant groups correspond to syntactic units is irrelevant. The simple effect of spacing, arbitrarily imposed, and uncontaminated by the presence of syntactic structure, could be directly observed in a comparison of recall accuracy for spaced and unspaced ungrammatical strings. If rejected, we next planned to test the hypothesis that

3. There is no difference in the effect of structural segmentation on the recall of grammatical and anomalous strings; this hypothesis involves the comparison of structurally spaced and unspaced strings, and states that the enhancing effects are evident for both types of strings. If accepted, we conclude that

(a) The primary influence of spacing is to accentuate the effect of syntactic structure on recall, a conclusion based upon the fact that what both string types have in common is syntactic organization. If rejected, we conclude either that

(b) The influence of spacing is to accentuate the effect of meaningfulness (i. e., words in familiar collocations) on recall, if structurally-segmented grammatical strings benefit from spacing but not structurally segmented anomalous strings; or that

(c) The effect of spacing is to facilitate the recall of material otherwise difficult to remember, if structurally segmented anomalous strings benefit from spacing but not structurally segmented grammatical strings. This conclusion assumes our replication of previous findings by Miller and Isard (1963) that grammatical strings are recalled more accurately than anomalous strings.

It was further planned to analyze errors observed in the recall of strings, under the several conditions of spacing and time-compression. Martin and his co-workers (1968a) found that in the recall of sentences, the likelihood that a word was forgotten depended upon its grammatical class. Adjectives, adverbs, and auxiliary verbs were most likely to be omitted and this evidence of a selective memory for grammatical class led the authors to suggest that, in analyzing incoming speech, the listener differentiates the key elements of a sentence (e. g., nouns serving as subjects and direct objects) from the less critical, more expendable elements (e. g., adjectives). It was proposed that the identification of key elements, the evaluative sorting and selection, is guided by the syntactic structure of the sentence. The susceptibility of adjectives to omission in sentence recall has also been reported by Matthews (1968). Our purpose, in this study, for examining recall errors was to determine whether temporal spacing and time compression influenced selective memory for grammatical classes.

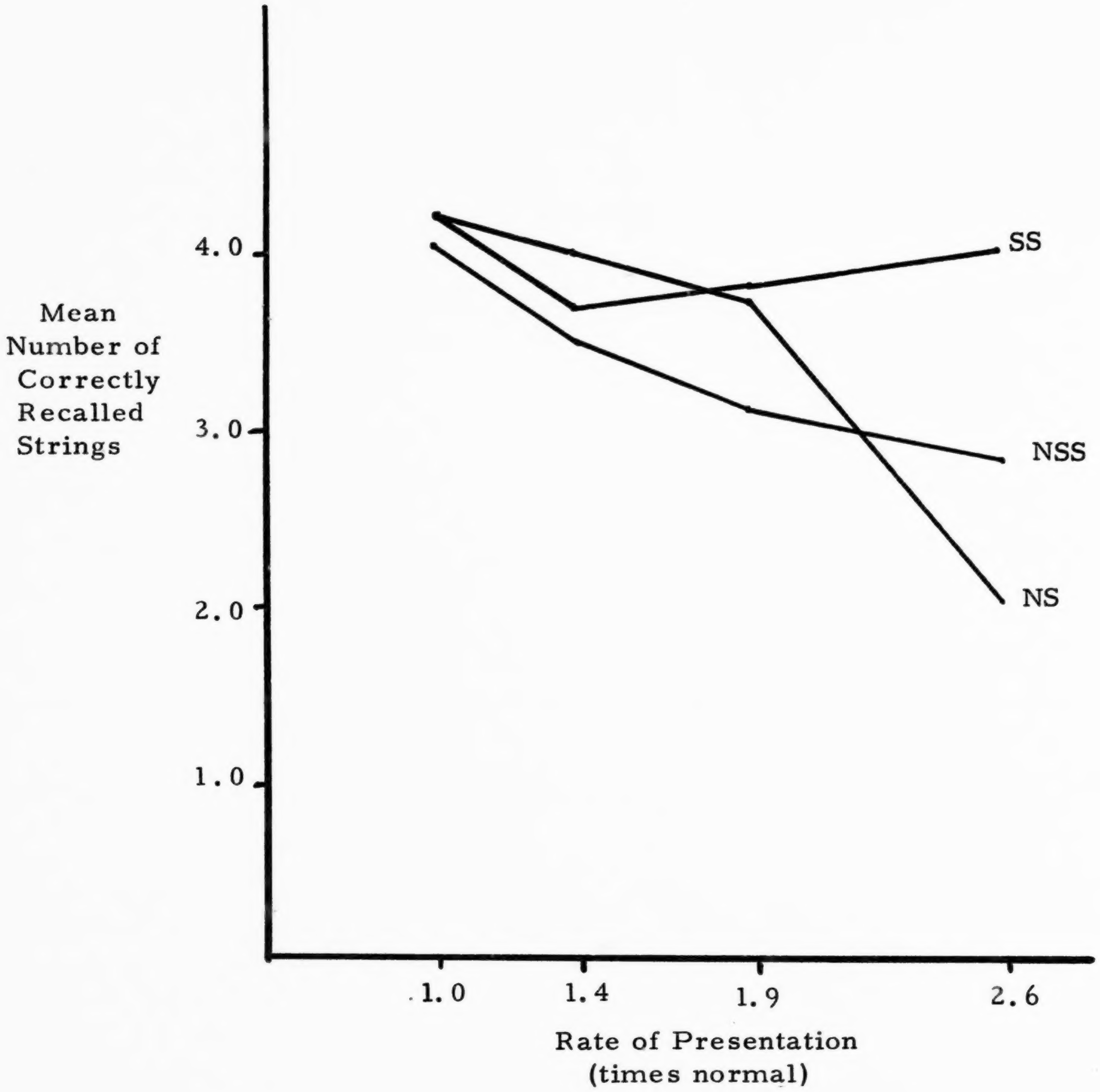

Figure 2. Recall accuracy of grammatical and anomalous strings heard at four rates of presentation when structurally spaced (SS), non-structurally spaced (NSS), or unspaced (NS).

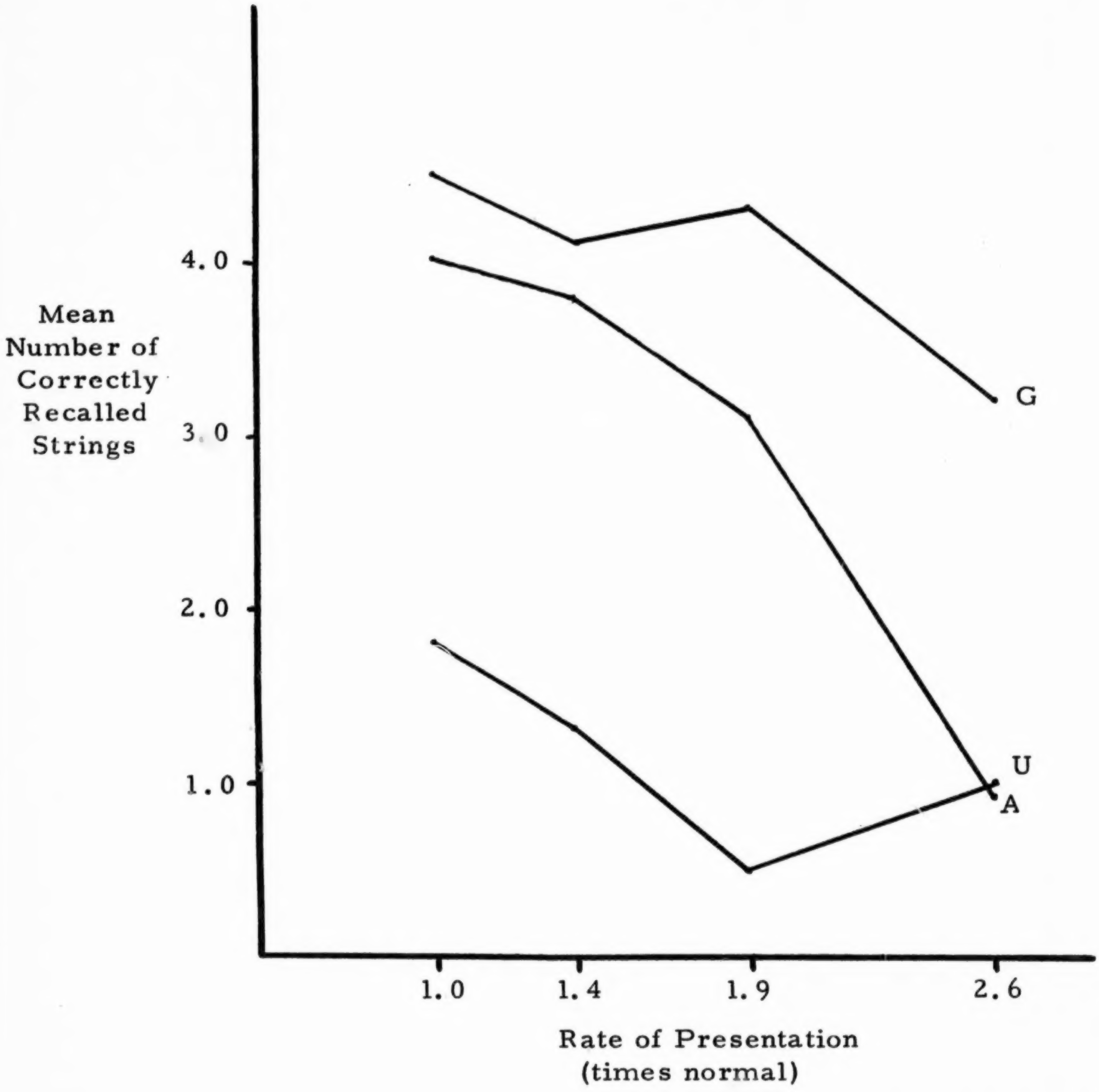

Figure 3: Recall Accuracy of unspaced grammatical (G), anomalous (A), and ungrammatical (U) strings heard at four rates of presentation.

RESULTS

Analysis for Effects of Three Main Variables on Recall.

The effects of temporal spacing, string type, and rate of compression on recall were determined by data analyses involving either two or three factor ANOVA designs with repeated measures (Winer, 1962). The results of the several analyses are briefly summarized below.

1. The Effect of Temporal Spacing on Recall. The structural segmentation of grammatical and anomalous strings produced more accurate recall than did either non-structural segmentation or non-structurally spaced strings. The F - ratio for the main effect was 3.43 (2, 45), $p > .05$; the results of a Newman-Keuls test of the difference between structural spacing and both non-structural segmentation or non-spacing were significant at the .01 level. Figure 2 shows the average number of correct responses of grammatical and anomalous strings, here combined, which have been segmented at structural and non-structural locations or not segmented at all.

There was no significant difference in the recall of spaced and unspaced ungrammatical strings ($F = 2.83$, 1 and 30 df).

2. The Effect of String Type on Recall. Subjects recalled grammatical strings more accurately than either anomalous or ungrammatical strings, and were more accurate in their recall of anomalous strings than of ungrammatical ones ($F = 2.56$, 1 and 45 df, $p > .01$). These results replicated previous findings by Miller and Isard (1963), who used masking noise rather than compression to degrade the signal. Figure 3 shows the average number of correct responses for unspaced grammatical, anomalous, and ungrammatical strings at four rates of presentation.

3. The Effect of Presentation Rate or Degree of Compression. The effect of increasing the degree of compression was to decrease the accuracy of recall. This was true for ungrammatical strings ($F = 6.90$, 3 and 90 df, $p > .01$), and for both grammatical and anomalous strings ($F = 38.43$, 3 and 135 df, $p > .01$), except between 1.4 and 1.9 times normal rate, which appeared to result in no significant decrement in recall accuracy.

4. The Joint Effects of Temporal Spacing and String Type on Recall at Various Rates of Compression. The analyses of variance revealed several significant interactions among the variables. For grammatical strings, structural segmentation produced recall superior to either non-segmented or non-structurally segmented strings only at the highest rate of compression, i.e., 2.6 times normal.

There was no significant difference between non-spaced and non-structurally spaced grammatical strings at any rate of presentation. The relationship between spacing and rate was similar for anomalous strings.

It was possible to compare all three string types for only that condition where the strings were non-spaced, since the "structureless", ungrammatical strings could be neither structurally nor non-structurally segmented. String type and rate were both significant as main effects ($F = 228$, 2 and 30 df, and $F = 56$, 3 and 45 df, $p > .01$). Furthermore, the significant interaction term ($F = 11.5$, 6 and 90 df) indicated that while at normal rate the unspaced anomalous strings were recalled almost as well as grammatical strings (respective means were 4.0 and 4.5), at the highest rate of compression, anomalous strings were recalled as poorly as the ungrammatical strings (means of .9 for both types). The greatest decrement over the range of presentation rates was observed for the anomalous strings. (See Tables 3 - 6).

At the same time, the facilitating effect of structural spacing on the recall of compressed strings was most marked for the anomalous strings. Table 7 shows the results of four separate analyses of variance which examined the effects of spacing and string type at each of the four compression rates. The advantage of structural segmentation clearly emerged only at the highest rate of compression (2.6 times normal), and the degree to which structural spacing improved recall accuracy depended upon the string type. The anomalous strings benefited more than did the grammatical strings, as indicated by the significant interaction term. The obvious point should be made that structural segmentation could be expected to markedly improve recall only if there were a considerable deterioration in performance for unspaced strings as a result of accelerating the rate of presentation. As already reported, increasing the degree of compression was more detrimental for unspaced anomalous than for unspaced grammatical strings. Hence, the anomalous strings had greater prospects for improvement.

To summarize, structural segmentation improved the recall of grammatical and anomalous strings only at the highest rate of compression. The structural segmentation of highly compressed anomalous strings improved recall to a relatively greater extent than it did for grammatical strings. The recall of ungrammatical strings did not seem to be markedly improved by spacing. In general, increasing the rate of compression had the effect of decreasing recall accuracy. Grammatical strings were easier to recall than anomalous ones, and these, in turn, were easier than ungrammatical strings.

Table 3

Mean Number of Strings Which A Subject Correctly Recalled (Maximum Number = 5.0)

STRUCTURALLY SPACED	Grammatical	4.50	4.37	4.25	4.56
	Anomalous	4.00	3.06	3.50	3.43
NON-STRUCTURALLY SPACED	Grammatical	4.37	4.56	3.50	3.50
	Anomalous	3.81	2.37	2.62	2.18
NON-SPACED	Grammatical	4.50	4.12	4.31	3.18
	Anomalous	4.00	3.81	3.06	0.87
SPACED UNGRAMMATICAL STRINGS		1.81	2.37	1.84	0.90
NON-SPACED UNGRAMMATICAL STRINGS		1.75	1.31	0.50	1.00
		1.0xN	1.4xN	1.9xN	2.6xN*

Rates of Compression

*N = Normal

Table 4

Summary of Analysis of Variance:
Grammatical and Anomalous Strings

Source of Variance	SS	df	MS	F
Between Subjects	191.334	47		
Spacing (A)	25.318	2	12.659	3.431*
Subj. W. Group	166.016	45	3.689	
Within Subjects	470.50	336		
String type (B)	112.667	1	112.667	256.644**
A B	1.567	2	0.783	1.783
B x Subj. W. Group	19.766	45	0.439	
Rate (C)	75.521	3	25.173	38.432**
A C	53.432	6	9.072	13.850**
C x Subj. W. Group	88.547	135	0.655	
B C	14.812	3	4.937	7.937**
A B C	20.142	6	3.357	5.397*
BC x Subj. W. Group	84.046	135	0.622	

* $p < .05$ ** $p < .01$

Table 5

Summary of Analysis of Variance: Ungrammatical Strings

Source of Variance	SS	df	MS	F
Between Subjects	108.875	31		
Spacing (A)	9.031	1	9.031	2.827 n.s.
Subj. W. Group	95.844	30	3.194	
Within Subjects	114.000	96		
Rate (B)	17.812	3	5.937	6.390**
A B	12.532	3	4.177	4.496**
B x Subj. W. Group	83.656	90	0.929	

**$p < .01$

Table 6

Summary of Analysis of Variance:

The effect of non-spaced string type (G, A, U)
and
rate of presentation in recall accuracy

Source of Variance	SS	df	MS	F
Between Subjects	290.000	32		
String Type (A)	272.078	2	136.039	227.76**
Subj. W. Group	17.922	30	0.597	
Within Subjects	211.007	144		
Rate (B)	81.078	3	27.026	55.48**
A B	46.922	6	7.820	11.52**
B x Subj. W. Group	21.922	45	0.487	
A B x Subj. W. Group	61.078	90	0.679	

** $p < .001$

Table 7

F-Ratios for Analyses of Effects of Spacing (Structurally Spaced vs. Non-Spaced) and String Type (G and A), and Their Interactions, at Each of Four Rates of Presentation

	PRESENTATION RATE			
	1.0	1.4	1.9	2.6
SPACING	0.000	0.742	0.328	40.062**
STRING TYPE	8.580*	17.203**	34.334**	91.071**
INTERACTION	0.000	6.514*	2.145	10.867**

* $p < .05$ ** $p < .01$

Outcomes of Hypotheses Testing. The first null hypohtesis was rejected on grounds that temporal spacing did result in more accurate recall than non-spacing. Moreover, structural spacing improved recall to a greater extent than non-structural spacing. The second null hypothesis was thereby rejected and we concluded that the increased accuracy could not be attributed simply to the effect of grouping, without an important role being assigned to syntactic structure. Finally, the third null hypothesis was partially rejected on the basis that while structural segmentation benefited both grammatical and anomalous strings, the recall of the latter was improved to a greater extent than the former. Thus, the effect of temporal spacing at structural loci was a mixed one: to accentuate the influence of syntactic structure on recall, and to enhance the recall of material otherwise difficult to remember.

Analysis of Errors in Recall. The remainder of the data analysis was concerned with the errors observed in the recall of grammatical and anomalous strings. We restricted the examination to incidents of omission, as had Martin, Roberts, & Collins (1968a), and sought evidence of a selective memory for grammatical classes and for an indication of the way this selectivity might be effected by temporal spacing and time-compression.

A preliminary examination of the nature of recall errors suggested that omissions tended to be "meaning preserving." That is, words essential to the meaning of a sentence were less likely to be omitted than words of secondary importance. This tendency was especially evident in grammatical sentences presented at normal rate, and was consistent with the results of a study by Mandler and Mandler (1964) which found that the key words of a sentence were learned more rapidly than the remainder of the sentence. As a crude index of the differential susceptibility for omission, we divided each string into two components. The "center" portion consisted of adjectives, adverbs, articles, and prepositional phrases. Thus, the center corresponded to the key elements of the sentence while the less critical elements constituted the adjunct. The following examples illustrate the classification (here the centers are italicized):

The *clock was built* by a Swiss watch maker.
Hunters simplify motorists across the line.
Colorless cellophane *packages crackle* loudly.
Colorless yellow *ideas sleep* furiously.

Tallies were made of the number of center and adjunct portions which exhibited at least one omission, and ratios were computed for grammatical and anomalous strings under the three temporal spacing conditions. If equal numbers of center and adjunct portions exhibited at least one omission, the ratio was 1.0. The smaller the ratio, the fewer the number of center omissions relative to adjunct omissions. The ratios are found in Table 8, where it can be seen that the relative number of center omissions was greater for non-structurally segmented. This trend was more accentuated for anomalous than for grammatical strings. While the ratios in Table 8 were obtained by combining the data from the various rates of compression, the observed relationships were not fundamentally altered when ratios were computed separately for each rate. At the rate 2.6 times normal, all ratios for non-structurally spaced and non-spaced strings exceeded 0.9 and there were no center omissions at all for structurally segmented grammatical or anomalous strings. Thus, the effect of increasing the rate of compression was to increase the relative frequency of center omissions, except for those strings which were structurally-spaced.

To allow a more refined analysis of the omission data, we restricted subsequent examination to two grammatical classes: nouns (representing the center portions of sentences) and adjectives (representing the adjuncts), and sought to identify some of the variables which determined the likelihood of their omissions in recall.

First of all, it was found that overall, adjectives were more likely to be omitted than nouns. Adjusting for the unequal frequencies with which nouns and adjectives occurred in the sentences, we found an $\underline{F}(1, 45) = 9.64$, $p > .01$. Furthermore, we isolated four variables which significantly influenced the incidence of noun and adjective omissions in recall.

1. String Length. The longer the string, the more likely were both nouns and adjectives to be omitted; $\underline{F}(2, 188) = 17.9$, $p > .01$.

2. String Type. Both nouns and adjectives were more likely to be omitted from anomalous strings than from grammatical strings; $\underline{F}(1, 94) = 116.9$, $p > .01$.

3. Position Within String. Both nouns and adjectives were more likely to be omitted from the right-most half of a string than from the left-most half; $\underline{F}(1, 94) = 12.8$, $p > .01$.

4. Presentation Rate. The higher the rate of compression, the greater the frequency with which nouns and adjectives were omitted; $\underline{F}(3, 282) - 31.4$, $p > .01$.

Table 8

Ratios of Center to Adjunct Omissions,
Combining Data from Various Rates of Compression

	Structurally Segmented	Non-Structurally Segmented	Non-Segmented
Grammatical Strings	0.000	0.500	0.625
Anomalous Strings	0.536	0.812	0.933

While these variables did influence the rate of omission for both nouns and adjectives, the effects were not uniform. These were several significant interactions. Specifically,

1. Relatively more adjectives than nouns were omitted from the longer sentences than was the case for the shorter sentences; F (2, 188) = 11.4, $p > .01$.

2. Relatively more adjectives than nouns were omitted from anomalous strings than from grammatical strings; F (1, 94) = 16.69, $p > .01$.

3. Relatively more adjectives than nouns were omitted from the right-most portion of a string than from the left-most portion; F (1, 99) = 12.2, $p > .01$.

Adjectives were less likely to be omitted from structurally-spaced sentences than from either non-structurally or non-segmented strings, F (2, 45) = 5.97, $p > .01$. (The latter two spacing conditions do not significantly differ from each other.) In contrast, temporal spacing had no significant effect on the omission of nouns; F (2, 45) = 1.90, n. s.

It is noteworthy that of the several variables studied, only compression rate had an effect which was comparable for both nouns and adjectives; F (3, 282) = 1.15, n. s. Nouns were not a privileged grammatical class, exempted from the degrading effects of compression. Rather, the effects were found to be impartially distributed, and this result is consistent with the more general finding that, as compression increased, the ratio of center-to-adjunct omissions approached 1.0.

In summary, an adjective tended to be omitted more often than a noun, and its omission was most likely to occur if it was located in the right-most position of a longer anomalous string presented at a high rate of compression. Structural segmentation had the effect of reducing the frequency of adjective omissions, but did not effect the omission of nouns. Increasing the rate of compression increased the incidence of omissions equally for nouns and adjectives. (See Tables 9-11)

DISCUSSION

Remembering requires an act of organization, and one of the basic ways to organize the elements of a stimulus array is to group them. In the recall of sentences, the grouping of words usually conforms to the syntactic structure of the sentences, and groups so formed are well-integrated functional units. That is, words which belong to the same

Table 9

Summary of Analysis of Variance:
The effects of spacing, position within the sentence,
and
sentence length on the omission of adjectives in recall

Source of Variance	SS	df	MS	F
Between Subjects	41.94	47		
Spacing (A)	6.09	2	3.05	3.81*
Subj. W. Group	35.85	45	0.80	
Within Subjects	166.67	240		
Position (B)	5.01	1	5.01	19.27**
AB	2.55	2	1.28	4.92*
B x Subj W. Group	11.78	45	0.26	
Length (C)	17.51	2	8.76	25.03**
AC	8.01	4	2.00	5.71**
C x Subj. W. Group	31.15	90	0.35	
BC	32.22	2	16.11	27.78**
ABC	6.60	4	1.65	2.84*
BC x Subj. W. Group	51.84	90	0.58	

* $p < .05$ ** $p < .01$

Table 10

Summary of Analysis of Variance:
The effect of grammatical class (noun vs. adjective),
within sentence position, and sentence length
on omissions during recall

Source of Variance	SS	df	MS	F
Between Subjects	29.055	95		
Gram. Class (A)	0.924	1	0.924	3.09 n.s.
Subj. W. Group	28.131	94	0.299	
Within Subjects	78.863	480		
Position (B)	0.859	1	0.859	13.03 **
AB	0.758	1	0.758	11.50 **
B x Subj. W. Group	6.198	94	0.066	
String Length (C)	4.424	2	2.211	19.56 **
AC	3.017	2	1.508	13.34 **
C x Subj. W. Group	21.278	188	0.113	
BC	5.302	2	2.651	17.21 **
ABC	8.059	2	4.029	26.16 **
BC x Subj. W. Group	28.969	188	0.154	

** $p < .001$

Table 11

Summary of Analysis of Variance:

The effects of grammatical class (noun vs. adjective), string type, and rate of presentation on omissions during recall

Source of Variance	SS	df	MS	F
Between Subjects	4.663	95		
Grammatical Class (A)	1.172	1	1.172	8.07**
Subj. W. Group	3.492	94	.037	
Within Subjects	14.457	672		
String type (B)	5.974	1	5.974	116.90**
AB	0.853	1	0.853	16.69**
B x Subj. W. Group	4.807	94	0.051	
Rate (C)	7.940	3	2.6466	31.43**
AC	0.290	3	0.097	1.15
C x Subj. W. Group	7.914	282	0.084	
BC	0.361	3	0.120	1.43
ABC	0.631	3	0.210	3.57*
BC x Subj. W. Group	23.682	282	0.084	

* $p < .05$ ** $p < .01$

group tend to more readily call forth or redintegrate the remaining words for the group, than words belonging to another group (Brent, 1969). In this sense, phrases are ordered groups of words, and sentences are ordered groups of phrases (Bower, 1968).

The findings of the present study can be interpreted as a demonstration of the organizing function of structurally inserted temporal spaces. By segmenting each string at its phrase boundaries, the entire string became easier to recall without error. The syntactically ordered string had an advantage in recall over the unordered string, and the effect of grouping was to allow this advantage to be realized under conditions which masked the presence of syntactic structure: when a string was highly compressed or composed of words in unfamiliar collocations (i.e., the anomalous string type). A similar demonstration of the effect of spacing was observed in the performance of intermediate level students of Russian who attempted to recall Russian sentences after once hearing them (Johnson & Friedman, 1969). In half the sentences, one space had been inserted between the independent clause and the remainder of the sentence, usually a prepositional phrase. The other sentences were not spaced. When students tried to recall an unspaced sentence they could often repeat the first few words. But then memory would fail, and the students would stop abruptly in mid-sentence. In contrast, students recalling a structurally spaced sentence were much more likely to finish it, however, incorrectly, in the sense that it was reasonably well-formed and complete grammatically and could be recognized as a sentence from its intonation pattern. On the basis of this evidence we may infer that a structurally segmented sentence was remembered as an integrated linguistic entity while the non-spaced sentence tended to be recalled as if it were a string of weakly related words.

The organizing function of temporal spaces can be also observed in data obtained by Suci (1969), who used the probe latency technique to examine the effects of structural spacing on recall. The method of probe latency exposes the listener to a complete sentence, and then presents one word from the sentence. The listener's task is to recall the word which immediately followed it as quickly as possible, and the response latency is measured. Each position in the sentence is probed (except for articles and the last word), and in the study discussed here, the sentences were of two types: grammatical and anomalous. Suci found that the effect of inserting a temporal space between the noun phrase and verb phrase was to "tighten" the temporal relationships within each syntactic group. That is, the recall latencies for words within a syntactic unit were shorter when the boundaries of the unit were marked by temporal spaces. Thus, the insertion of spaces at structurally meaningful points within a string had the effect of strengthening the bonds between individual words belonging to the same syntactic unit. The organizing effect of spacing was comparable for both grammatical and anomalous strings.

Further evidence for the grouping effect of temporal spacing is found in the analysis of omissions data reported in the present paper. Grammatical classes were not equally susceptible to omission. Adjectives were more likely to be omitted than nouns, and were especially likely to be forgotten when the strings were long, when the adjectives occurred toward the end of a string or were used in an anomalous construction. The length of the string, the position of the word within the string, and the level of meaningfulness were conditions which influenced the degree of difficulty in recalling words in a string, and when memory was burdened, selective forgetting tended to occur. This vulnerability of adjectives has been previously noted by Martin, Roberts & Collins (1968a) and by Matthews (1968), who have all proposed that the listener stores adjectives and other qualifiers in a way which differs from the storage of nouns and other more essential elements of a sentence. It is significant, then, that the effect of structural segmentation was to reduce the rate of omission for adjectives, but not for nouns. Nouns themselves appear to serve as organizing elements in the recall of noun phrases (Donlinsky & Michael, 1969), and perhaps this function is reflected in their priority status in memory. We may conclude, therefore, that one effect of temporal spacing at structural junctures was to accentuate the relationship between noun and adjective, to reinforce the connective bond in memory.

Basing the interpretation of present findings upon the role of organization in memory may appear to ignore the possible effects of temporal spacing on perception. It has been argued that the listener must recognize the syntactic structure of a sentence before it can be understood (e.g., Fodor, Bever, & Garrett, 1968), and even theoretical approaches which deny the necessity for complete syntactic analysis usually specify that the incoming stream of speech must be perceptually segmented into phrase-like units for subsequent semantic processing (Quillian, 1968). Thus, alternative explanations for the facilitating effect of temporal spacing might stress the role of segmentation in the recognition of underlying syntactic structure. Spacing could either mark phrase boundaries or provide perceptual processing time at critical junctures within the sentence. In actual fact, of course, the theoretical terms which we use to treat perceptual recognition are often used to describe memory as well (Bower, 1967). Our understanding of memory and perception are intertwined, and Bower found in trying to develop a model of memory that similar explanatory concepts could account for the distortions of perception and memory caused by degrading the quality of the stimulus. Thus, the way listeners remember sentences is probably related to the way they understand them, and the grouping of words may play a role in both processes.

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SUPPLEMENTARY STUDIES

A. Recognition Accuracy of Time-Compressed Words in Context.

In our previous studies of string type, rate of compression, and temporal spacing, the measure employed was accuracy of string recall. In this experiment, we explored the use of a recognition measure. The materials were those described earlier in this report. Grammatical, anomalous, and ungrammatical strings were presented at four presentation rates, under three conditions of temporal spacing: structural, non-structural, and no spacing at all. The subjects were 41 college students (17 males, 24 females) who listened to each string, and immediately afterwards were shown that string in written form. One word in the sentence (either a noun or adjective) had been changed, and the subjects' task was to identify the changed word. Whether the substituted word was in the right or left-hand portions of the string was determined from the Gellerman table for left/right sequences. For grammatical strings, the substituted word was a synonym of the original.

The rather striking result of this study was that of 2,460 possibilities of error (60 sentences times 41 subjects), there were only three errors in recognizing, or not recognizing, the word which had been changed. Clearly, recognition accuracy in this highly restricted situation remained relatively unimpaired by any of the experimental treatments.

B. String Recall and Construction.

This study was designed to examine some of the correlates of recall accuracy for grammatical and anomalous strings (i.e., the Miller-Isard sentences used in the temporal spacing research). Two nouns and one adjective were selected from each of the 60 strings and subjects (N = 22) were asked to perform two tasks:

1. Judge the likelihood that the two nouns and one adjective would occur together in the same sentence in natural language. Judgments were expressed on a 5 point scale, ranging from very likely (1) to very unlikely (5).

2. Create a meaningful sentence using the two nouns and one adjective.

Correlations were computed among subjective judgements of likelihood, the length of the constructed sentences, the length of time subjects took to begin constructing the sentences (i.e., response latency), and the recall accuracy of the strings from which the nouns and adjective

Table 12

Correlations among string recall and construction tasks

	Recall accuracy	Subject judgments	Sentence length	Latency
Recall accuracy	1.0	-.643	-.677	-.588
Subject judgments		1.0	.786	.859
Sentence length			1.0	.714
Latency				1.0

Note: All correlations were significant beyond .01 level.

were selected. Recall data had been obtained from another group of subjects. The correlation matrix is found in Table 12, where it can be seen that all variables were significantly related. Strings which were easily recalled tended to contain nouns and adjectives which were judged likely to occur together in natural language (i.e., they formed "natural" and familiar collocations), and which could be rapidly combined as elements of short, uncomplicated sentences. For these tasks, there appeared to be a close relationship between encoding and decoding processes.

C. Comparison of Compressed Speech Prepared by the Tempo-Regulator and by Computer.

This study compared the intelligibility of compressed speech prepared on the Tempo-Regulator with speech samples compressed via computer. The computer-produced compressed speech, prepared for us by the National Security Agency, was made available in two forms: (1) a monaural version, and (2) a dichotic version, in which the discarded portion of the speech signal was recorded on the second channel. The listener heard both tracks simultaneously.

The text material were three passages on the history of 17th century England, and multiple choice comprehension tests were administered immediately following the presentation of each passage.

The design is summarized in Table 13. All passages were presented at a rate 1.86 times normal, with the order counter balanced for method of compression.

Analysis of comprehension test scores from 44 subjects indicated no significant difference among the treatments. Thus, there was no evidence that computer-compressed speech was more intelligible than samples produced by the Tempo-Regulator, nor was dichotic listening superior to monaural.

D. Relationships Among Measures of Listening Comprehension.

I. Factor Analysis of Comprehension Measures.

The ways to measure the listener's comprehension of a passage is restricted only by the limits of the experimenter's imagination. Faced with a multitude of diverse measures, it is difficult for the experimenter to choose the most relevant and useful technique or instrument. One basis for choice is to choose that measure which

Table 13

Design and data analysis of study comparing compressed speech prepared by the Tempo-Regulator and by Computer (monaural and dichotic)

	PASSAGE		
	A	B	C
Tempo Regulator	G_1	G_3	G_2
Compressed/Monaural	G_2	G_1	G_3
Compressed/Dichotic	G_3	G_2	G_1

t tests (N = 44)	
Tempo-Regulator vs. Compressed Monaural	t = -1.90, ns
Tempo-Regulator vs. Compressed Dichotic	t = -1.45, ns
Compressed Monaural vs. Compressed Dichotic	t = 0.49, ns

has most in common with all other presumed measures of listening comprehension. If we assume that what all potential measures have in common is the aspect of comprehension, then the measure most similar to all others should offer the "purest" assessment of comprehension. This is the rationale for a factor analytic approach described in this study.

Intercorrelations were computed among the following ten measures:

Variable 1. The Nelson Denny Reading Test (comprehension).

Variable 2. A standardized multiple choice comprehension test based upon the content of a history of 17th century England.

Variable 3. The probe latency technique. Subjects listened to a complete sentence, and then a portion of it was repeated. The subjects' task was to complete it.

Variable 4. The order of appearance. Subjects rank-ordered selected sentences from a passage they had previously heard, putting them in their sequence of occurance in the text.

Variable 5. The Brown Carlson Listening Test.

Variable 6. The Michigan Adult Reading Test, a cloze-type instrument.

Variable 7. Recognition of noun phrases. After listening to a passage (excerpted from a longer text), subjects identified from a list of phrases those which had occurred in the passage they heard. Distractor items were noun phrases, similar in content and style to the test items, selected from the longer text.

Variable 8. Sentence recognition. Similar to Variable 7, except that entire sentences were identified rather than noun phrases.

Variable 9. Recognition of paraphrased sentences. Similar to Variable 8, except that the sentences were paraphrased to express the same ideas in words different from those used in the passage.

Variable 10. Recognition of frequently used words. Subjects were presented with ten pairs of words from the passage they had previously heard. One word of the pair had been used only once, the other had occurred 5 - 8 times. All were content words. The task was to identify the word in each pair which occurred more frequently than the other.

Scores from 71 subjects were obtained for each variable, and a factor analysis performed on the correlation matrix.

Two dimensions (with eigen values exceeding 1.0) emerged from the factor analysis. The first variable accounted for 46% of the variance and was defined by variable numbers 3, 1, 5, 6, and 2. The second variable accounted for an additional 12% of the variance and was defined by variables 9, 4, and 6. Note that variable 6, the Michigan Adult Reading Test, was the one measure with appreciable loadings on both dimensions. In Figure 4, the loadings of each variable on the two dimensions is plotted.

We conclude from this analysis that cloze-type measures of comprehension (represented here by the Michigan Adult Reading Test) are most similar to the other nine measures, and of this set is the "purest" instrument.

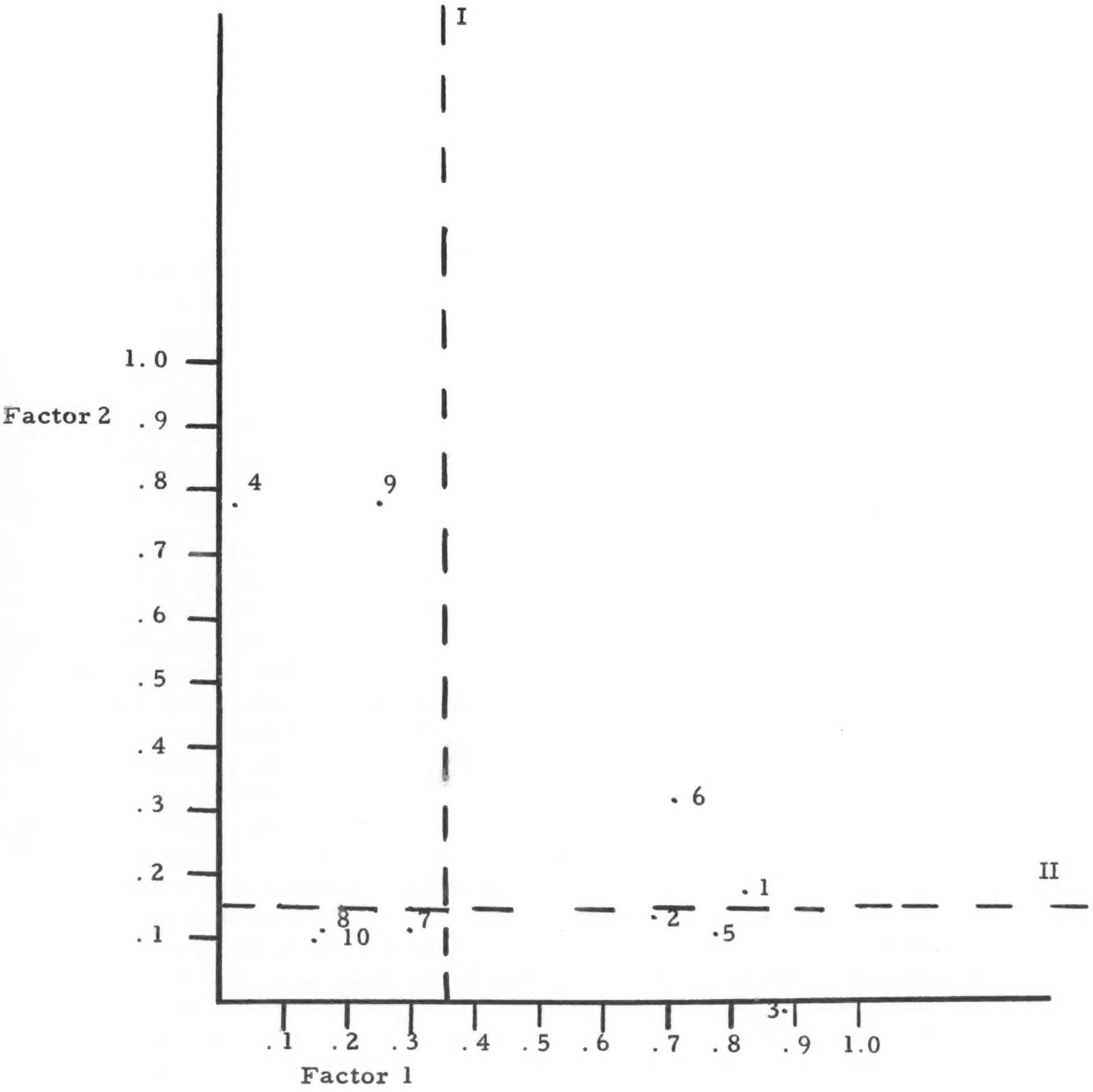

Figure 4. Loadings of 10 variables on two comprehension factors. Points in the upper right quadrant, set off by dotted lines, correspond to tests with loadings above the median on both dimensions.

PART III

ON UNDERSTANDING TIME-COMPRESSED SPEECH: THE INTERACTION BETWEEN TEMPORAL SPACING AND SEMANTIC ABILITY

This study attempted to replicate and integrate findings from two hitherto separate lines of inquiry: our study of individual differences in the ability to comprehend connected discourse when heard at high rates of presentation, and our study of the effects of temporal spacing on the ability to recall time-compressed sentences. Main conclusions from these studies will be briefly reviewed in order to provide background for the four studies designed to extend, clarify, and synthesize our earlier findings.

The study of sources of individual variation in the comprehension of compressed speech (Friedman and Johnson, 1968) was based on the hypothesis that understanding a highly-compressed speech signal may be dependent upon certain skills which are less discernibly implicated at normal or near-normal speech rates. The possibility that some special competence is needed to comprehend highly compressed speech was consistent with conclusions drawn from studies of individual differences in perceptual motor skills which have demonstrated changes, as a task becomes more difficult, in the relative contribution which specific skills make to the performance of the task. The rationale for the individual differences study was, first, to identify some of the correlates of listening comprehension, both at normal and compressed speech rates; and second, to inspect the correlation data for patterns of change associated with increases in the rate of compression. A multiple regression analysis of six predictor variables found that, as a general tendency, the magnitudes of the correlations (and corresponding beta weights) between predictor and comprehension tests decreased as rate of compression increased. Running counter to this trend was one of the tests from the experimental battery developed to measure hypothetical abilities in the Guilford structure-of-intellect model. (Guilford, 1967). This test, the Best Trend Name, was constructed as a measure of the ability to "evaluate semantic relations" (designated EMR).

The structure-of-intellect model postulates five intellectual operations which act upon four areas of content to yield six products or outcomes. The evaluation of semantic relations is but one of 120 abilities which exist, according to the model. The evaluative operation is a process of comparing and matching items of information according to some criterion (e.g., identity, similarity, satisfaction of class membership, or consistency) and of making decisions with respect to the meeting of that criterion. Evaluation does not involve the production of a response to match a standard stimulus, but only the comparison and choice among a set of responses which are already available. The rate at which the matching is done is also a component of this ability. It is a significant historical note that prior to Guilford's classification theory, the evaluative operation was variously termed perceptual speed, speed of judgment, and speed of association. (Hoepfner, Nihira, and Guilford, 1966). The evaluative operation in EMR is specific to semantic content -- i.e., natural language or experimental materials which exhibit the lexical and/or syntactic characteristics of natural language -- and the product is a judgment about relations:

> We can ask whether the relation of A to B is the same as that of C to D. We can also ask whether the relation of P to Q is consistent with the relation of K to L. If we are told that P is greater than Q and that Q equals K, then it would be inconsistent to say that K is greater than P. (Guilford, 1967 p. 193).

In evaluating semantic relations, a pair of words with an apparent relationship between them is presented to the subject, along with four alternative pairs. The subject must choose which comes nearest to expressing the same relation:

Given pair: BIRD - SONG

Alternative pairs: FISH - WATER
MAN - LETTER
PIANIST - PIANO
HORSE - RANCH

In this example, MAN - LETTER makes the closest analogy to BIRD - SONG. A bird produces a song as a man produces a letter.

It was the EMR ability, a skill to compare semantic relations with accuracy and rapidity, which was observed to become more highly correlated with comprehension as rate of compression increased. This pattern suggested that EMR was a special competence needed to comprehend highly compressed speech.

Another strand in our research has been the investigation of temporal spacing as it effects the comprehension of compressed speech. (Johnson, Friedman, and Stuart, 1969). We have found that the selective insertion of temporal spaces within sentences, at major syntactic junctures, has a marked effect in increasing the recall accuracy of the sentences, especially when highly compressed. Temporal spacing appears to help the listener group words in a sentence into structurally-related units, and it is this meaningful organization of the stimulus material which makes it easier to remember (and probably to perceive). We reported, for example, that one effect of spacing is to strengthen the relationship in memory between a noun and its adjective modifier; the adjective is less likely to be omitted in recall if the noun phrase in which it appears is bounded by a temporal gap. Words which occur together in a phrase, or sentence, are related syntactically and semantically, and the effect of spacing is to facilitate the recognition and recall of the related elements. On this basis, we may hypothesize that Guilford's EMR ability is involved in the perception of and memory for the relational structures of the sentence and will interact with temporal spacing in comprehension and recall.

In the four studies reported below, these findings were extended to other types of material, other measures of comprehension, different loci for temporal spacing, alternate measures of the EMR ability. We also sought to determine the relationship between EMR and temporal spacing.

STUDY I

The purpose of this study was threefold:

(1) to replicate the effects of temporal spacing for connected discourse, rather than for the discrete, unrelated sentences used in previous studies;

(2) to replicate the effects of temporal spacing when comprehension was measured by the Michigan Adult Reading Test (Greene, 1964), a cloze-type test, rather than the sentence recall task employed in our earlier experiments;

(3) to compare the effects of placing temporal spaces between (but not within) successive sentences in a passage of connected discourse. Brent (1969) has suggested that

> The integration of sentences into paragraphs is a process which unfolds in time. One may completely comprehend the meanings of each of the sentences in the paragraph, as coherent functional units, without being able to "group" or "utilize" the integrating story of the paragraph as a whole. (pp 77 - 78).

Brent's data indicated that between 1 and 3 seconds (as very rough approximations) are required for integrating the sentences into a paragraph unit, but the data did not support any interpretation that time was necessary to integrate the elements within sentences. The study reported here was designed as a partial test of Brent's suggestions about the need for time between, but not within, sentences.

METHOD

Subjects. Undergraduates from the University of Maryland were recruited to serve as paid subjects. A total of 83 participated, 47 of whom were women students. At the beginning of the study, they were randomly assigned to three experimental groups (I, II, and III) with sizes of 27, 27, and 29, respectively.

Materials. The passage presented to the subjects dealt with bird lore of the Pacific, and was the same text upon which the Michigan Adult Reading Test (or MART) had been based (Greene, 1964). The passage was divided into two sections. Part A contained 598 words in 39 sentences, with an average sentence length of 15.3 words. Part B contained 723 words in 37 sentences, with an average sentence length of 19.4 words.

Both parts were tape recorded in three different versions and each was then compressed on the Tempo-Regulator by a factor of 2.5 times original speed. Thus, a passage originally recorded at about 150 words per minute was compressed to approximately 375 words per minute. The three versions were:

1. Within Sentence Spacing. Temporal gaps of one second duration were inserted at major phrase boundaries, as determined by an immediate constituent analysis of each sentence. On the average, temporal spacing was introduced after every fourth or fifth word. Total playback time for Part A, after compression, was 1'58" and for Part B, 2'22".

2. Between Sentence Spacing. Temporal gaps of about three seconds' duration were inserted between sentences, rather than within them. Total playback time for Part A, after compression, was 2'01" and for Part B, 2'23".

3. No Spacing. No temporal gaps were introduced, either within or between sentences. Total playback time for Part A, after compression, was 1'26" and for Part B, 1'45".

To measure subjects' comprehension of the passage, two cloze type tests were constructed. For Part A, we made use of the MART, which was already available. The format of the test consisted of a printed text of the passage with blanks in place of the fifty deleted words. Subjects responded by writing in their guesses of the missing words. The test was timed. For Part B, a similar instrument of 50 items was constructed, with instructions and scoring procedure identical to those prepared for the MART.

Procedure. All three experimental groups heard Part A first, followed by Part B. Comprehension tests were adminstered immediately after the presentation of each part. For Group I, Part A was spaced within sentences and Part B was spaced between sentences. For Group II, Part A was spaced between sentences and Part B was spaced within sentences. Group III heard the non-spaced versions of Parts A and B.

RESULTS

The effect of inserting temporal gaps within and between sentences in the experiment described earlier was assessed using a Lindquist (1953) Type II design.

Spacing within sentences appeared to produce significantly higher scores on the cloze tests than did spacing between sentences. ($F = 25.89$, df = 1, 52, $p > .01$). But a further comparison of comprehension test scores for those passages where gaps were inserted between sentences and those without any temporal spacing at all revealed no significant differences. A test of the difference between cloze scores for Groups II and III (based on Part A) yielded a t of .924, df = 54; for Groups I and III (based on Part B), a t of -.490, df = 54. See Table 14.

CONCLUSION

These results are consistent with earlier findings that the selective insertion of temporal gaps at structural locations within sentences aided the comprehension of compressed speech. Temporal spacing within sentence boundaries raised comprehension test scores at least 30% over scores obtained for non-spaced passages or passages spaced between (but not within) sentences.

TABLE 14

Summary of Analysis of Variance and t-Tests

Source of Variation	SS	df	MS	
Between S's	3161.52	53		
G (AB)	181.48	1	181.48	3.
SS WG	2980.04	52	57.31	
Within S's	1489	54		
Passage (A)	625.93	1	625.93	56.
Spacing (B)	286.82	1	286.82	25.
Error	576.26	52	11.08	

$^{**}p < .01$

STUDY II

The preceeding Study I demonstrated that in listening to compressed speech, subjects more accurately understood passages which were temporally segmented at syntactic junctures within each sentence than passages which were segmented between (but not within) sentences, or passages which were not segmented at all. In this experiment we attempted to determine the frequency with which sentences should be internally segmented for optimum levels of comprehension when passages are compressed. Specifically, we asked whether sentences should be segmented at phrase boundaries (producing relatively short strings of words) or at clause boundaries (producing longer strings). The critical question was, then, the optimum size of the syntactic unit for comprehension at increasing rates of presentation.

METHOD

Subjects. Fifty-four undergraduates were recruited from area colleges and universities to serve as paid subjects; 28 were women students, 26 were men. All were native speakers of English and had normal hearing.

Materials. A magazine article about jazz guitarist Charlie Byrd was divided into three approximately equal sections, designated passages A, B, and C. Three different versions of each passage were then prepared:

1. Temporal spacing between phrases.

An immediate constituent analysis identified major phrase boundaries in each sentence, and taped versions of the three passages were recorded with temporal spaces inserted at every boundary. Average phrase length was 3.6 words.

2. Temporal spacing between clauses.

Sentences were so divided that clause units were kept intact. In recording this version of the three passages, temporal spaces were inserted to mark off major clause constructions. Average unit length was 9.7 words.

3. No spacing.

The three passages were recorded by the narrator who read at a "natural" pace, without introducing prolonged pauses within sentences.

Table 15

Playback Times for Passages (in minutes and seconds)

	Passage	Presentation Rate		
		Normal	2.0 x N	2.75 x N
No Spacing	A	6.49	3.25	2.30
	B	7.11	3.38	2.38
	C	6.43	3.22	2.27
Phrase Spacing	A	15.47	7.50	5.46
	B	17.07	8.27	6.17
	C	15.16	7.31	5.32
Clause Spacing	A	10.55	5.24	4.00
	B	10.50	5.24	3.57
	C	10.39	5.16	3.52

Table 16

Design of the Study. Passages are Designated A, B, and C. Each Group Contained Six Subjects

		Normal Rate	2.0 x Normal	2.75 x Normal
No Spacing	G_1	A	B	C
	G_2	B	C	A
	G_3	C	A	B
Phrase Spacing	G_4	A	B	C
	G_5	B	C	A
	G_6	C	A	B
Clause Spacing	G_7	A	B	C
	G_8	B	C	A
	G_9	C	A	B

Each passage was compressed on the Tempo-Regulator to a rate 2.0 and 2.75 times normal.

The total playback times for the 27 taped versions (three passages x three spacing conditions x three rates of presentation) are presented in Table 15.

Comprehension Measure. A cloze test was constructed for each passage by randomly deleting 20 lexical words. The format of the test was a typed transcript of the passage with blank spaces where deletions occurred. Copies are found in the Appendix.

Procedure. Subjects were randomly assigned to nine experimental groups (n = 6). Groups I, II, and III heard the three passages without any temporal spacing within sentences. Groups IV, V, and VI heard the passages with spacing at phrase boundaries, while Groups VII, VIII, and IX heard the passages with spacing at clause junctures. Every subject heard one passage at each of the three rates, and the order of presentation was always the same: first normal, then 2.0 times normal, and finally 2.75 times normal. For each spacing treatment, the passages were counterbalanced so that every passage was heard at every rate. The design is summarized in Table 16.

All subjects in an experimental group participated at the same time. A tape was played to the group and immediately as its conclusion, the comprehension test based on that passage was administered. Three tapes and tests were given in a single session.

RESULTS

Data, the number of correct responses on the cloze tests, were analyzed using a two factor ANOVA design with repeated measures on the second factor. Results are presented in Table 17. Both main effects -- spacing and rate -- were found to be significant, and there was no appreciable interaction between them. As can be seen from Figure 5, phrase spacing produced consistently higher mean scores than did clause spacing, which itself produced higher scores than no spacing at all. And the decrements associated with increasing rates of presentation were comparable for all three spacing conditions. Duncan's Multiple Range Test confirmed the superiority of phrase spacing over clause spacing, and clause spacing over no spacing. See Table 18.

Table 17

Analysis of Variance: Effects on Comprehension of No Spacing, Phrase Spacing, and Clause Spacing at Three Rates of Presentation

Source of Variation	ss	df	ms	F
Between Subjects	1079.89	53		
Spacing (A)	189.21	2	94.61	5.42^*
Subj. W. Group	890.68	51	17.46	
Within Subjects	782.76	108		
Rate (B)	123.29	2	61.65	10.22^*
AB	44.32	4	11.08	1.84
B x Subj. W. Group	615.15	102	6.03	

$^*p < .01$

N = 54, n = 18

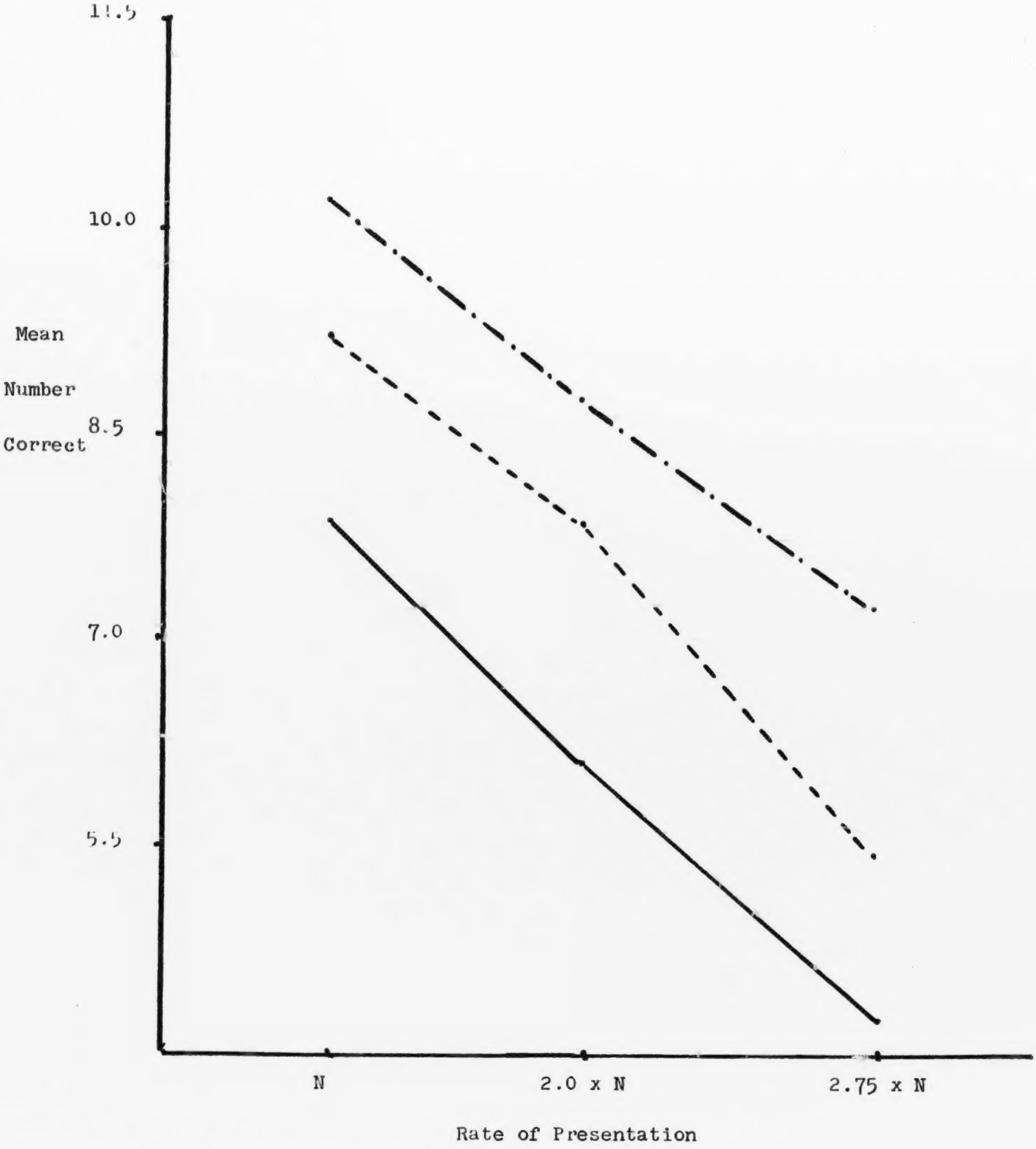

Figure 5

Key: No-spacing ————

Clause-spacing -------

Phrase-spacing ·-·-·-·-

Table 18

Multiple Range Test Applied to the Differences between No Spacing (M = 6.17), Clause Spacing (7.65), and Phrase Spacing (M = 8.81) Treatment Means. The Analysis of Variance is Given in Table 3.

	No Spacing	Clause Spacing	Phrase Spacing	Shortest Significant Ranges
No Spacing		1.48*	2.64*	$R_2 = .218$
Clause Spacing			1.16*	$R_3 = .227$

*$p < .01$

CONCLUSION

These results considered together with the findings reported earlier, present a very consistent and replicable picture of the effect of temporal spacing. The insertion of spaces at major phrase boundaries leads to so marked an improvement in the comprehension of connected discourse that the use of temporal spacing in educational applications of compressed speech would appear to be mandatory, especially at the higher rates of compression.

An unexpected finding, one which deserves further study, is the enhancing effect of temporal spacing at normal speaking rates. The insertion of spaces at phrase boundaries resulted in a much higher degree of comprehension than did the unspaced treatment, even at the relatively slow rate of approximately 175 words per minute. This is surprising because listening to phrase-spaced material at normal speed was, subjectively, a tedious experience, requiring more than twice as much time as the unspaced version. Nevertheless, the effect on comprehension appeared to be clear cut, and the implications of this finding, if replicated, could be very significant for the auditory learning of natural language materials.

STUDY III

Earlier in this study we reported an attempt to identify correlates of the ability to understand time-compressed speech (Friedman & Johnson, 1968). A number of possible predictor variables were examined and, in general, the pattern we found was a decrease in the size of the correlations between predictor and comprehension tests as rate of compression increased. Running counter to this tendency was the Best Trend Name test, a measure of the ability to evaluate semantic relations (designated EMR in the Guilford structure-of-intellect model). In this study we attempted to replicate earlier findings using measures of comprehension and EMR ability which differed from those employed in the previous research.

METHOD

Subjects. A total of 51 undergraduates were recruited from Washington area universities to serve as paid participants in the study. The subjects (26 male, 25 female) were all native speakers of English and were without significant hearing or language deficits. Mean age was 22 years, 7 months.

Materials. A battery of tests was administered to the subjects consisting of the:

1. Lorge-Thorndike verbal intelligence tests (five subtests, level 5, form A).

2. The Sentences and Space Relations subtests of the Differential Aptitude Test battery.

3. The vocabulary section of the Nelson Denny reading test.

4. Three subtests of the Modern Language Aptitude Test: Phonetic Script (Part II), Spelling Clues (Part III), and Words in Sentences (Part IV).

5. The Remote Associates Tests, a measure of verbal "creativity."

6. Twenty-three tests intended as measures of the hypothetical abilities of the Guilford structure-of-intellect model. In Table 19 the tests are categorized according to the abilities in the Guilford model. Note that two tests, Best Trend Name and Verbal Analogies, are measures of the ability to evaluate semantic relations (or EMR). Both tests are multiple-choice in format, and require subjects to choose a response which is consistent with an implied relationship among a set of stimulus words. Brief descriptions of the tests are found in the Appendix.

The prose passages presented to subjects and the cloze-comprehension tests were described in Study II. Rates of compression were normal (N), 2.0 times N, and 2.75 times N.

Procedures. Subjects listened to tape recordings of the prose passages in order of increasing compression, with a comprehension test administered immediately following each passage presentation. All subjects heard passages at all three presentation rates.

FINDINGS AND ANALYSIS

Four tests were selected as most promising predictor variables and a multiple correlation analysis was performed, with comprehension scores at three rates serving as the dependent variables. Results are found in Table 20, and in essential aspects are comparable to earlier findings (Friedman & Johnson, 1968). Most significant was the decline

Table 19

Twenty-three semantic tests used in this study, classified according to the hypothetical abilities each measures in the Guilford structure-of-intellect model.

		Operation				
		E	N	D	M	C
		Evaluation	Converg^{t}-produc^{n}	Diverg^{t}-produc^{n}	Memory	Cognition
Product	Units	Sentensence Double Description	Word-Group-Naming Picture-Group-Naming		Recalled Words Picture Memory	
	Classes	Class-Name-Selection Best-Word-Class	Word Grouping Group Classifica^{n}		Classified Information Picture-Class Memory	
	Relations	Best-Trend-Name Verbal Analogies	Inventive-Opposites Associations		Remembered Relations Recalled Analogies	
	Systems	Word Systems Unlikely Things	Temporal Ordering Picture Arrange^{t}		Memory for Events	
	Transformations					
	Implications					

Table 20

Prediction of Listening Comprehension at Three Rates of Presentation (N = 51)

		Predictors					Criteria		
		1	2	3	4		5	6	7
Mean		6.15	1.31	2.62	5.45		0.92	0.76	0.61
S.D.		1.81	0.24	4.37	1.42		0.28	0.36	0.41
			Intercorrelations					Beta-Weights	
Space Relations (DASR)	1	1.00	0.13	-0.07	0.10		0.03	0.06	0.23
Verbal Analogies (VA)	2	0.13	1.00	0.01	0.35		0.32	0.33	0.39
Recalled Analogies (REAN)	3	-0.07	0.01	1.00	-0.02		-0.07	0.09	0.01
Vocabulary (NDVB)	4	0.10	0.35	-0.02	1.00		0.34	0.41	0.01
					Multiple R		0.56	0.62	0.48
					F Ratio		5.17**	7.28**	3.36*
			Validity Coefficients					b-Weights	
Normal rate 1.0 x N	5	0.11	0.45	-0.08	0.46	1	0.00	0.01	0.05
2.0 x normal	6	0.14	0.48	0.08	0.53	2	0.38	0.49	0.65
2.75 x normal	7	0.28	0.42	0.00	0.17	3	0.00	0.01	0.00
						4	0.07	0.10	0.00

df = 4, 46

**$p < .01$

*$p < .05$

in the relative contribution made by vocabulary knowledge to the overall prediction, as rate of compression increased. In contrast, EMR (measured here by the Verbal Analogies Test) became more effective as a predictor when compression rate increased. These changing patterns in relative predictiveness are graphically depicted in Figure 6, where it can be seen that at the 2.75 rate, scores on the Nelson Denny Vocabulary test made no contribution whatever as a predictor variable.

Further examination of Table 20 reveals that the Space Relations subtest of the DAT battery also gained in predictiveness as compression rate increased. We have noted previously (Friedman & Johnson, 1968) that the nature of the task required by this test(i.e., matching geometric figures) involves an evaluation of relations in the spatial domain similar to EMR in the semantic domain. Thus, the results of the present study tend to confirm the earlier findings that the ability to evaluate semantic relations plays a significant role in the comprehension of time-compressed speech.

STUDY IV

In this study, we sought to relate two separate findings: (1) that the ability to evaluate semantic relations becomes an increasingly effective predictor of comprehension at high rates of compression, and (2) that the insertion of temporal spaces at phrase boundaries results in improved comprehension, especially at high rates of compression. The fact that the predictive role of EMR and the effects of temporal spacing on recall are both most discernible when speech is highly compressed suggested that the ability to evaluate semantic relations may be involved in the listener's use of phrase-structure in the processes of sentence comprehension and memory.

METHOD

Data collected earlier (Study II) was subjected to further analysis. Three groups of subjects had listened to three prose passages at three rates of compression (normal, twice normal, and 2.75 times normal), prepared using three types of temporal spacing. That is, the materials were either non-spaced, phrase-spaced, or "clause"-spaced. Comprehension was measured by cloze-type tests. Performance under these conditions was then related to the listeners' abilities to evaluate semantic relations, as measured by the Verbal Analogies test from the Guilford experimental battery.

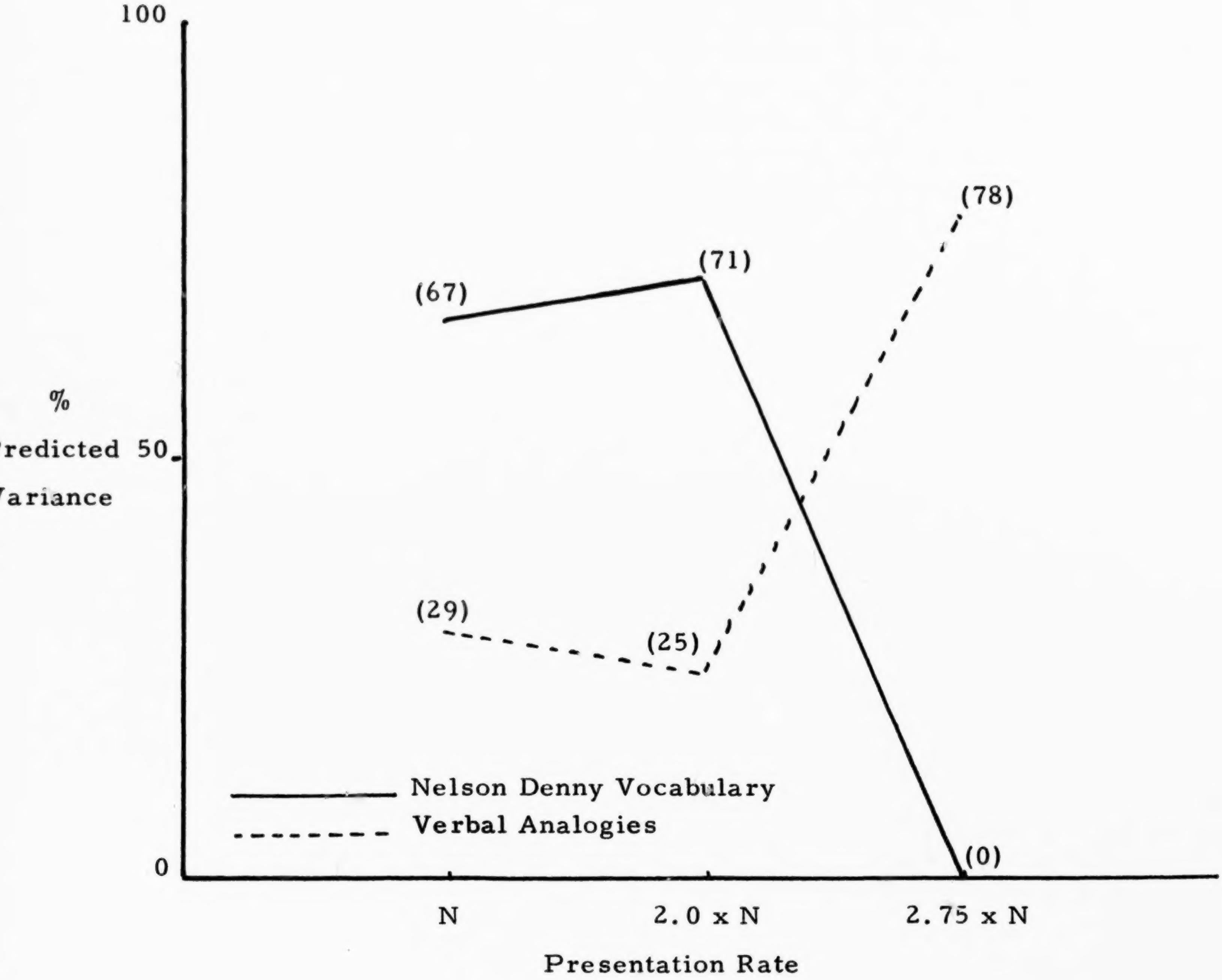

Figure 6. The proportion of total predicted variance for which the Nelson Denny Vocabulary Test and Verbal Analogies Test (a measure of EMR) accounted in a multiple correlation study of variables which predicted cloze-comprehension. Passages were presented at three different rates.

FINDINGS AND ANALYSIS

Three separate analyses of variance were performed to determine the effects of EMR and presentation rate on the comprehension of passages, temporally spaced in three different ways. Summaries are found in Table 21a, b, and c where it can be seen that while presentation rate was a significant variable, regardless of type of spacing, EMR was a significant main effect only when the passages were phrase-spaced. Under this condition, the interaction between EMR and rate was also significant. These data are graphically presented, in a somewhat condensed form, (i. e., the twice normal rate is omitted) in Figure 7, and corresponding t - tests which compare cloze-comprehension scores of subjects grouped according to their performance on the Verbal Analogies test are reported in Table 22.

Two specific findings should be emphasized:

(1) The ability to evaluate semantic relations best differentiated between listeners -- on the basis of their cloze-comprehension scores -- when phrase-spaced material was presented at highly compressed rates (i. e., twice normal and above).

(2) EMR did not differentiate between listeners at normal presentation rate, and the difference in comprehension between high and low EMR groups was smallest for phrase-spaced materials.

Thus, it appears that the insertion of spaces at phrase boundaries reduced the disparity in comprehension between listeners at normal presentation rate -- when listeners are grouped according to EMR. This finding may imply that effective listeners attend to the phrase structure of a sentence, while ineffective listeners do not -- unless they are compelled to do so by temporal spacing. Once the sentence is segmented into "natural" units, and the duration of each unit reduced by speech-compression, the ability to evaluate semantic relations is involved in the rapid perceptual processing of linguistic elements within the unit. The type of basic task represented by the Verbal Analogies test has long been considered to measure perceptual speed, speed of judgment, or speed of association (Hoepfner, Nihira, and Guilford, 1966). One interpretation of these data is that EMR measures individual abilities in rapidly determining the meaningful connections between words or concepts occurring together within a phrase, or some larger natural unit.

Summary tables for three analyses of variance of the effects of the ability to evaluate semantic relations (EMR) -- as measured by Guilford's Verbal Analogies Test -- and three rates of presentation on the cloze-comprehension of prose passages, prepared using three different methods of temporal spacing.

Table 21a

Non-Spaced Text

Source of Variation	df	MS	F
Between Subjects	17		
A (EMR)	1	72.50	4.30
Subjects within groups	16	16.86	
Within Subjects	36		
B (rate)	2	69.64	13.96*
AB	2	4.16	0.84
B x subjects within groups	32	4.99	

*p < .01

Table 21b

"Clause"-Spaced Text

Source of Variation	df	MS	F
Between Subjects	15		
A (EMR)	1	33.15	2.02
Subjects within groups	14	16.56	
Within Subjects	32		
B (rate)	2	57.19	12.51*
AB	2	16.35	3.58
B x subjects within groups	28	4.57	

*$p < .01$

Table 21c

Source of Variation	df	MS	F
Phrase-Spaced Text			
Between Subjects	16		
A (EMR)	1	114.51	13.52*
Subjects within groups	15	8.54	
Within Subjects	34		
B (rate)	2	41.46	7.34*
AB	2	510.36	90.33*
B x subjects within groups	30	5.65	

*p. $< .01$

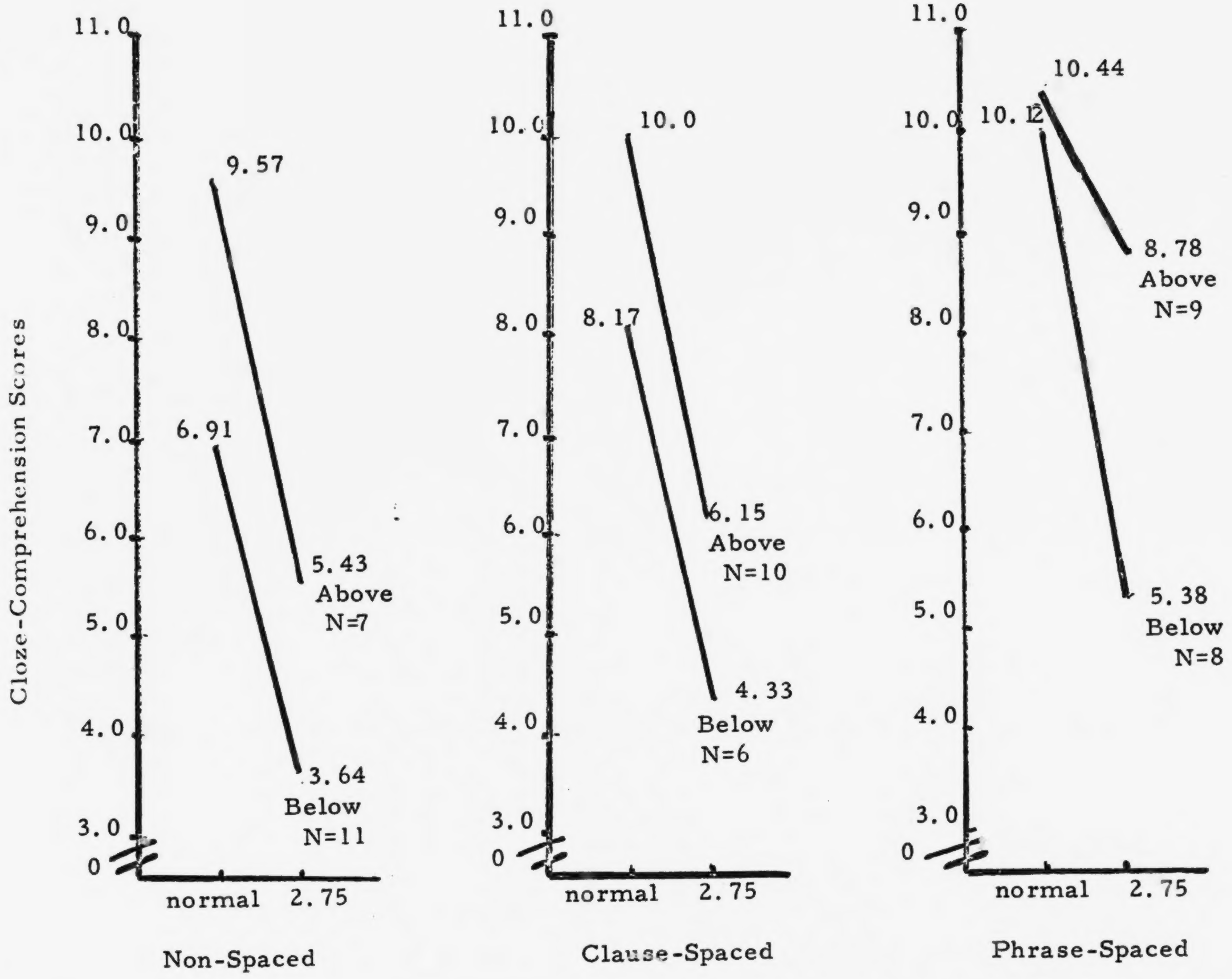

Figure 7. Graphical comparisons of cloze-comprehension scores for subjects scoring above and below the group mean on the Guilford Verbal Analogies test. Note that data for passages presented at twice normal rate have been omitted in order to condense the graph sizes.

Table 22

A series of *t*-tests comparing cloze-comprehension scores for subjects scoring above and below the group mean on the Guilford Verbal Analogies Test

		Rate of Presentation		
		Normal (N)	2.0 x N	2.75 x N
Type of Temporal Spacing	Non-Spaced	.81	.80	.70
	Clause-Spaced	.70	.49	.65
	Phrase-Spaced	0.20	2.08*	2.52*

*$p < .05$

DISCUSSION

The value of the Verbal Analogies test as a predictor of comprehension at high rates of compression may be due, in part, to a resemblance between the nature of the task incorporated in the test and the nature of the basic operation involved in understanding natural language, as this process is described in a recent theory advanced by Quillian (1966, 1967). A few of the most significant points of similarity will be noted here.

In the Verbal Analogies test, subjects are given an item in the following form:

TRAFFIC : SIGNAL as RIVER ; __________ A. bank
B. dam
C. canal
D. sand bags

They are instructed to choose one of the four alternatives which is related to RIVER in the same way that SIGNAL is related to TRAFFIC. To answer correctly, the subject must discover an attribute of both SIGNAL and TRAFFIC which is shared by RIVER and one of the four available choices. Specifically, the subject must recognize that a signal stops the flow of traffic in somewhat the same way that a dam stops the flow of a river.

It is precisely this relating of concepts by attribute-matching which is involved in comprehension. As Quillian depicts the process:

> It seems generally agreed that understanding text includes recognizing the structure of relations between words of the text . . . The overall effect of these processes is to encode the text's meaning into some form more or less parallel to that in which the subject's general knowledge is stored, so that its meaning may be compared to that knowledge, and perhaps added to it. (Quillian, 1966, p. 53).

Quillian's "path finding" theory of comprehension is too detailed for us to attempt more than a cursory exposition here. In broad outline, however, the theory states that words are encoded in semantic memory as attribute-bundles and these attributes are extensively cross-indexed. The interlocking network of attributes which characterizes the organization of semantic memory permits two words to be compared for shared meaning by searching through their respective attribute fields to discover any intersect or overlap in attributes. Sometimes two words will not share any immediate attributes, but both will be related -- in different ways -- to some third word. Quillian suggests that the length of the search required to find a path connecting two words is an index of their semantive similarity. If the path is long and circuitous, a sentence in which these words co-occur may be difficult to understand. If a path cannot be found which links the words of a sentence, the sentence is meaningless. In Quillian's view,

> The cognitive processing which a reader must carry out in order to (understand a text) is based on his finding, for certain pairs . . . of concepts which the text associates, some way in which those same concepts previously have been, or intelligibly may be, associated, given his general memory. (Quillian, 1966, p. 70).

Path finding makes use of the syntactic information in a sentence in several ways:

(1) to form units. Data from Quillian's simulation studies suggest that readers or listeners "bite off" segments of text for intensive processing. Left-to-right segmentation is achieved by applying unit-forming rules which are purely syntactic in nature, and results in phrase-groupings which contain two or three lexical items. Our own finding that the insertion of temporal spaces at phrase boundaries facilitates comprehension is compatible with the aspect of Quillian's theory.

(2) to determine the order in which words in a unit are related. Once a phrase has been isolated for processing, syntactic information is used in deciding the order in which the attribute fields of constituent words are to be searched.

(3) to relate one phrase to another. Following the processing of all words in a phrase, it is linked to the preceding portion of the text, and this higher-order connection is guided by syntactic cues.

On the basis of these considerations, we may formulate the following hypothesis: that EMR, the ability to evaluate semantic relations, is involved in the path-finding process essential to the comprehension of connected discourse, and that the Verbal Analogies test measures individual speed and proficiency in finding connecting paths between concepts.

CONCLUSION

It is not surprising that the ability to evaluate semantic relations is implicated in the comprehension of compressed speech. Lenneberg (1969), for example, has noted that:

> virtually every aspect of language is the expression of relations. This is true of phonology (as stressed by Roman Jakobson and his school), semantics, and syntax. For instance, in all languages of the world words label a set of relational principles instead of being labels of specific objects . . . Further, no language has ever been described that does not have a second order of relational principles, namely, principles in which relations are being related, that is, syntax in which relations between words are being specified. (pp 640 - 1).

There are relationships among sentences also, as attested by the fact that readers can identify paragraph boundaries in unindented prose passages (Koen, Becker, and Young, 1969) and can reduce the content of a paragraph to summary form (Jones, 1967). Comprehension as a process can be understood, then, as the recognition of relationships, within and between sentences, and the accurate encoding of this information. A listener can take advantage of the many structural cues which indicate relationships, especially at the sentence and paragraph level, and it seems plausible to suppose that an important aspect of selective listening involves the directing of attention to relational cues.

Selective attention in listening for relational cues occurs on at least two levels:

1. Listening for cues which identify the "core-meaning unit" within the sentence. In investigating the effects of compression on the recall accuracy of sentences, and sentence-like strings, we found that errors in recall tended to be meaning-preserving; specifically, that nouns and verbs essential to the meaning of the sentence were more likely to be accurately recalled than were the less essential, modifying adjectives and adverbs. Similar findings were reported by Mandler and Mandler (1964) who conducted a study of sentence memorization, and concluded that

> What Ss remember after one trial is not determined by primacy or recency, but frequently represents the core-meaning unit of the sentence. These meaning units may or may not be syntactically intact sentences, but they do frequently represent the main communicative message of the sentence. In some cases the main message stored

> in memory may not be the content meaning of the sentence but some structural aspect of the sentence carried by marker words. (p. 201)

Other findings that adjectives and other qualifiers in a sentence are more difficult to recall than nouns was presented by Matthews (1968) who speculated that qualifiers are either stored separately in memory from the more essential parts of the sentence, or are discarded altogether at the time of reception. Further evidence for differential forgetting over word classes, with adjectives and adverbs being especially vulnerable, was summarized by Martin, Roberts, and Collins (1968). These authors suggested the hypothesis that

> word classes, when in a sentential context, are differentially attended ... That Ss selectively focus on key elements of the input string, with grammatical structure acting as the functional stimulus that directs his selection. (p. 566)

There is, as yet, no direct evidence that the rules governing this selective attentiveness are the rules of grammar. The case remains largely inferential.

2. Listening for cues which identify the independent element in a group of sentences, the recognition of the "topic" sentence.

The recall of a passage of connected discourse appears to proceed in a manner roughly analogous to the recall of single sentences. In a study of differential patterns in the recall of prose passages, Gomulicki (1956) found that listening appears to give almost equal attention to everything at the beginning of a passage with the result that the opening words often are recalled nearly verbatim. But when the direction of the passage becomes apparent, the material assumes a figure-ground relationship, with attention focussed increasingly upon the more important elements. Recall then becomes more selective, and the longer the passage, the greater is the degree of selectivity.

Gomulicki suggests that the process of selective attention seems to develop concurrently with the process of understanding a passage while hearing it and these two processes share at least one important feature: selectivity implies a ranking of elements according to importance, while the understanding of a passage requires that the relative importance of its elements be accurately perceived.

The listener may be assisted in evaluating the importance of material in a passage by certain structural or organizational devices which Woolley (1966) has described as the English hyper-syntax, i.e., the syntactic constraints beyond sentence boundaries.

Woolley has argued that every well formed text contains at least one independent sentence. A sentence is independent if its apparent information content in isolation of the text is not appreciably different from its apparent information content in context. Remaining sentences in the text are dependent and are linked by various structural devices to the independent sentence, and/or to one another. Sentences are structurally inter-related in two important ways:

(a) by tagmeme structure -- which involves a nesting of higher-level constructions within higher-level constructions. This organization of the text includes the independent sentence (s) and all dependent sentences linked by conjunctions which are either right-binding (e.g., a question mark) or left-binding (e.g., the conjunctions "and," "but," "likewise," "meanwhile.", etc.). Such a classification of linking devices enabled Woolley to devise a system for graphically representing the relational structure of a well-formed text.

(b) by the tie structure -- which involves relations which cut across tagmeme structure such as anaphora (i.e., words or phrases which refer back to an earlier word or phrase in a passage), lexical ties (e.g., a repetition of the same noun phrase as subject of successive sentences), and dependency ties (e.g., a missing but necessary part of the syntactic structure of a sentence which is supplied by another sentence). Certain formal regularities in the use of tie structures, especially anaphora, have been studied by Olney (1964), and recent research findings tentatively suggest that passages containing numerous anaphoric terms tend to be difficult to read (Bormuth, 1968). It is reasonable to hypothesize that a more profound view of "readability" or "listenability," and the psycholinguistic factors which influence these, would involve the nature of the relationships among sentences in the text, as much as variables such as word frequency and length, or sentence length and complexity. The linguistic research of Woolley, Jones, and Olney provide the concepts and methods necessary to open this area to systematic research for the first time.

Our continuing studies of the effect of speech compression on comprehension have produced strong evidence that processing time is necessary at certain critical junctures within the sentence if the listener is to be able to accurately recall its "core-meaning unit." These junctures correspond to the major phrase boundaries, as determined by immediate constituent analysis, and their importance to comprehension is consistent with the position that the phrase is a natural linguistic unit. There is some basis for hypothesizing that processing time is also necessary for understanding the relationship between discrete sentences. Brent (1969), for example, reported results of an experiment which supported his hypothesis that the integration of sentences into paragraphs is a process which unfolds in time. Apparently, one may completely comprehend the meanings of each of the sentences in a paragraph, as coherent functional units, without being able to "grasp" or "utilize" the integrative structure of the paragraph as a whole. This act of integration requires additional processing time, perhaps of the magnitude of one to three seconds.

In summary, we have cited evidence from our own studies of compressed speech and from related psycholinguistic experiments which suggests four generalizations:

1. Whether a listener is decoding a single sentence or a well-formed text, the act of understanding is intricately associated with the process of selective attention: to identify the "core-meaning" of the message, as distinguished from its adjunct components (i. e., qualification, modification, comment, etc.).

2. In the identification of the "core-meaning", the listener is guided by structural cues: syntactic markers within the sentence, hyper-syntactic markers between sentences.

3. The perceptual processing of these structural cues requires time at critical junctures: temporal intervals at phrase boundaries for syntactic-semantic analysis within the sentence, temporal intervals between sentences for integration of each sentence with the portion of the text which preceded.

4. There is an implied hierarchy of processes: the evaluative judgments about the relative importance of elements within a sentence must be completed before that sentence can be evaluated for its relative importance to the text in which it occurs.

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RECOMMENDATIONS FOR FUTURE RESEARCH

The findings of this project have reinforced the concept of listening as a highly selective, delicately timed process sensitive to temporal and linguistic features of oral language. The unique approach taken, of co-manipulating temporal and linguistic features has worked well for the material studied. Time compression has proved an invaluable research tool when used with temporal spacing and behaviorally relevant linguistic features. Since listening is done in a limited amount of time set by the temporal and sequential character of speech, a reduction in the time available for processing results in a failure to complete all the necessary activities which lead to full comprehension. A systematic reduction permits experimental identification of the priorities assigned to the listening activities which accompany speech, and thereby identify the subskills of listening behavior. The research performed in this project for single sentences needs to be extended to higher level activities and longer durations of speech. The relationships within complex sentences and between sentences grouped together form the next logical body of language to be studied for a more complete understanding of listening behavior. The authors have proposed such research in a proposal submitted to the Office of Education entitled "listening as a Selective Process: Some Temporal Factors in the Perception of Speech".

Listening behavior is a universal phenomenon fundamental to language and communication and yet is still a somewhat neglected field of inquiry. We hope not only that we have contributed research of scientific merit, but that we will have stirred the thinking of the research community in this vital area. The urgency of educational needs cannot be overstated. The training of skilled listeners can open the educational world to millions of people who cannot read well, and enhance the education of those who can. This can only be accomplished through a greater understanding of the fundamental nature of listening, a goal which we shall continue to pursue.

APPENDIX A

Miller-Isard Experimental Sentences

Speed: 175 Words per Minute

(Structurally Segmented)

U. Elected the door / President lilting / complicated the.

A. The club / fastened / the controversial lilting formula.

G. The wealthy child / attended / a private school.

U. Fitted Bible the / school filthy / academic a.

G. The Holy Bible / inspired / a deep reverence.

G. Fragrant yellow roses / bloom / annually.

G. The clock / was built / by a Swiss watch maker.

A. Bears / shoot work / at the country.

U. Between / gadgets highways passengers / the steal.

A. The odorless child / inspired / a chocolate audience.

A. The musicians / explained / the worst oak bill.

A. Total coffee / loses / eternal spots.

U. Pleased falling / newly the cigarette / everybody.

G. A witness / signed / the official legal document.

U. The removed / a was maker lion / event by volunteer.

A = Anomalous string

G = Grammatical string

U = Ungrammatical string

Miller-Isard Experimental Sentences

Speed: 250 Words per Minute

A. Accidents / carry honey / between the house.

U. Autographs / Latin mare worked / sticky the.

A. The nationally disguised toys / covered / customers.

A. The secret humid actor / aroused / hay.

G. Hunters / shoot elephants / between the eyes.

G. Union leaders / call / sudden strikes.

U. Fooled / colored gently / the restaurant cancer.

U. Sleep roses / dangerously / young colorless.

A. A storm / slew / the official diamond corruption.

U. Spread / packages annually / political all.

G. The academic lecture / attracted / a limited audience.

U. Hay miracle / weather / signed frenzied the.

G. A magazine / exposed / the shocking political corruption.

G. The frenzied Latin rhythm / aroused / passions.

A. Hunters / simplify motorists / across the hive.

A = Anomalous string

G = Grammatical string

U = Ungrammatical string

Miller-Isard Experimental Sentences

Speed: 350 Words per Minute

U. Needed advertised / cleverly the toys / streets.

G. The gently falling snow / covered / streets.

U. Describes ink / attacks / instant baseball.

U. Lure / parties explorers / cheaper union.

G. The trash / was removed / by a lazy garbage collector.

A. Colorless yellow ideas / sleep / furiously.

G. Bright fies / lure / rainbow trout.

A. Tropical cars / call / rainbow neighbors.

G. A storm / prevented / the annual company picnic.

U. A legal / glittering the / exposed picnic worm.

U. A diamond / shocking the prevented / dragon witness.

A. The frenzied gray ingredient / frayed / autographs.

G. Sloppy fielding / loses / baseball games.

A. The Holy wrapper / attracted / a filthy school.

A. Romantic ink / follows / wasted games.

A = Anomalous string

G = Grammatical string

U = Ungrammatical string

Miller-Isard Experimental Sentences

Speed: 450 Words per Minute

U. A fire-breathing / official the appraised / corruption storm.

A. The academic liquid / attended / a deep bar.

U. Attracted wrapper / the reverence / private odorless a.

G. Gadgets / simplify work / around the house.

A. Trains / steal elephants / around the highways.

A. Bright parties / challenge / cheaper strikes.

A. Spilled chaos / saves / baseball lovers.

U. Explained the / officers bold / healthy gay the.

G. The brightly colored toys / pleased / children.

G. Colorless cellophane packages / crackle / loudly.

G. Loud parties / wake/ sleeping neighbors.

U. Tempers / young rhythm / ate secret the.

G. Bears / steal honey / from the hive.

U. Became lecture / the bar deep / wealthy a.

A. The sticky young rhythm / ate / wonders.

A = Anomalous string

G = Grammatical string

U = Ungrammatical string

Miller-Isard Experimental Sentences

Speed: 175 Words per Minute

(Non-Structured Segmentation)

U. Elected the door / President lilting / complicated the.

A. The club fastened the controversial / lilting / formula.

G. The wealthy / child attended a / private school

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G. Fragrant / yellow / roses bloom annually.

G. The clock was built by a / Swiss watch / maker.

A. Bears shoot work at / the / country.

U. Between / gadgets highways passengers / the steal.

A. The odorless / child inspired a chocolate / audience.

A. The musicians explained the / worst oak / bill.

A. Total / coffee loses eternal / spots.

U. Pleased falling / newly the cigarette / everybody.

G. A witness signed the / official / legal document.

U. The removed / a was maker lion / event by volunteer.

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Speed: 250 Words per Minute

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A. The nationally / disguised / toys covered customers.

A. The secret / humid / actor aroused hay.

G. Hunters shoot / elephants between / the eyes.

G. Union / leaders call sudden / strikes.

U. Fooled / colored gently / the restaurant cancer.

U. Sleep roses / dangerously / young colorless.

A. A / storm slew the / official diamond corruption.

U. Spread / packages annually / political all.

G. The academic / lecture attracted a limited / audience.

U. Hay miracle / weather / signed frenzied the.

G. A magazine exposed the / shocking political / corruption.

G. The frenzied / Latin / ryhthm aroused passions.

A. Hunters simplify / motorists across / the hive.

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Miller-Isard Experimental Sentences

Speed: 350 Words per Minute

U. Needed advertised / cleverly the toys / streets.
G. The gently/ falling snow covered / streets.
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U. Lure / parties explorers / cheaper union.
G. The trash / was removed by a lazy / garbage collector.
A. Colorless / yellow / ideas sleep furiously.
G. Bright / flies / lure rainbow trout.
A. Tropical / cars call rainbow / neighbors.
G. A storm prevented the annual / company / picnic.
U. A legal / glittering the / exposed picnic worm.
U. A diamond / shocking the prevented / dragon witness.
A. The frenzied / gray / ingredient frayed autographs.
G. Sloppy / fielding loses baseball / games.
A. The Holy / wrapper attracted a / filthy school.
A. Romantic / ink follows wasted / games.

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A. Trains steal / elephants around the / highways.

A. Bright / parties challenge cheaper / strikes.

A. Spilled / chaos saves baseball / love.

U. Explained the / officers bold / healthy gay the.

G. The brightly / colored toys pleased / children.

G. Colorless / cellophane / packages crackle loudly.

G. Loud / parties wake sleeping / neighbors.

U. Tempers / young rhythm / ate secret the.

G. Bears steal / honey from the / hive.

U. Became lecture / the bar deep / wealthy a.

A. The sticky / young / rhythm ate wonders.

A = Anomalous string
G = Grammatical string
U = Ungrammatical string

APPENDIX B

Comprehension Test for Passage A

The Cloze Test

Directions

This test consists of the passage you have just heard. At various points in the passage, single words have been left out and replaced by numbered blanks. Your task is to fill in each blank with the same word that was taken out.

It generally helps if you will look quickly over the entire comprehension passage to get the overall idea, then work on the individual items. The words remaining around each blank can help you figure what the missing word must be.

There are twenty (20) items. You will have twenty (20) minutes to work on this section.

To record your answers, write the word you think of in the space on the answer sheet. The answer spaces are numbered from 1 to 20 to correspond to the numbers of the blanks in the passage. Try not to leave any questions unanswered. If you can not do one item, go on and come back to it later. The score will simply be the total of correct responses. There is no penalty for guessing, so you should try every item.

If you have any questions, ask them now; if not, wait for the signal to turn the page. Do not start until told to do so.

Part A

Charlie Byrd can play _____1_____ better than Segovia, classical music better than Lonnie Johnson. He has far more proficiency than Django Reinhardt, Carl Kress or Charlie Christian ever had. He is more versatile than any classical guitarist, alive or dead. "None so far, is as thoroughly and convincingly at ease, in both _____2_____, as guitarist Charlie Byrd," the New York jazz critic, Nat Hentoff, has written. Byrd himself thinks that Julian Bream, a classical-only guitarist from England, is supreme on the instrument. But the greatest all-around guitar player in the world, almost everyone else now agrees, is balding-but-youthful, 40-year-old Charles Lee Byrd.

He first picked up a guitar at age 10, in his native Chuckatuck, a very small town in Virginia, at the suggestion of his father, Newman Byrd, a general storekeeper and amateur musician who is now retired. Young Charlie was also inspired by the guitar work of several _____3_____, all talented amateurs, and by Jack Ramsey and other folk-music masters in the region. He played guitar and trumpet in his school band and at age 13 performed in his first professional date.

"It was a four-piece kids' band," Byrd recalled not long ago. "We played for a Saturaday night dance in a hall in Carrollton, Virginia, and were supposed to be hipper than the _____4_____ music the customers expected. We did Benny Goodman tunes, but we flopped. By the end of the evening, only the _____5_____ was on the floor, dancing by himself, and denouncing his customers as squares. It was a very funny scene, but I think were only paid $5 for the whole band, instead of $5 each as we expected."

Undaunted, Byrd kept playing guitar during his two years of business administration study at Virginia Polytechnic Institute. During World War II, he served in Germany with the 63rd Infantry, in heavy action in the Mannheim-Heidleberg sector, later, with the 424th Army Special Forces Band, under direction of Marty Faloon, another guitarist. In Paris, Byrd met and jammed with Reinhardt, who was by then, a jazz _____6_____. The gypsy virtuoso performed his stringed gymnastics, in swing, with his deformed fret hand, and inspired Byrd to continue his musical career after the war. In 1946, Byrd played his first job with a union card, in a quintet at a _____7_____ near Norfolk. He played a guitar with conventional electric amplification, and doubled as a vocalist. As Byrd recalls it, "I tried to sing like Nat King Cole. I had more hair on my head then."

Then to New York. Byrd still holds an American Federation of Musicians card in the New York local, 802, as well as one in No. 161, the ______8______ local. He played first in Greenwich Village nightclub ______9______ led by Sol Yaged, a clarinetist in the Benny Goodman school. "Of course, he was supposed to sound as much as possible like Charlie Christian." From 1946 to 1950, he also worked in small groups with such Dixieland ______10______ as Freddie Slack and Joe Marsala. He won praise from Eddie Condon, the saloon proprietor and veteran rhythm section guitarist who had played with the Chicago Rhythm Kings in the 1920's. But he had soured on the jazz life -- the night hours, the mediocre pay, the ______11______.

"I was fed up," says Byrd. "I had gone home for Christmas and had applied to enter William & Mary College. I had just about decided to do other work, and be an amateur guitarist on the side." But two days before the ______12______ at his parents' house, he received a telephone call from Adelaide Robbins, a ______13______ he had worked with. She asked him to join in a Christmas Eve gig (a one shot job) in Binghampton. "For some reason, I went," Byrd said, "and it was a turning point in my life." He played another club date in the city with a group whose former vocalist was an attractive young girl named Virginia Darpino. She met Byrd on one of her frequent return visits to see her old friends. The following ______14______ Byrd and Miss Darpino, a native of Endicott, N. Y., were married in Binghampton, and she persuaded him to remain a ______15______.

With her Italian-style charm (and exotic Chinese and Indian cooking), Ginny Byrd also persuaded her husband to pursue his growing interest in classical guitar. They moved to Washington so he could study with Sophocles Pappas, "the only classical guitar teacher approved by the G.I. Bill." They both kept working together, at home and professionally, as they still do: Mrs. Byrd sang with the trio at the White House party and still serves as Byrd's secretary and ______16______.

In 1954, Byrd auditioned for Andres Segovia, the master classical guitarist, and won a scholarship to study during that summer with the great Spaniard in Siena. Every other day for six weeks, Byrd and fifteen other ______17______ gathered around Segovia to study his ______18______. The experience was another turning point for Byrd. "It revealed Segovia as a man, instead of a god."

For a musician who came up the traditional jazz route, Charlie Byrd leads a sensationally quiet life. And although he almost turned in his union card to go back to college, as a ______19______ man with financial security, choice working hours, and a reputation as the most ______20______ guitarist on earth, Charlie Byrd shows no sign of being fed up with anything today.

APPENDIX C

Comprehension Test for Passage B

The Cloze Test

Directions

This test consists of the passage you have just heard. At various points in the passage, single words have been left out and replaced by numbered blanks. Your task is to fill in each blank with the same word that was taken out.

It generally helps if you will look quickly over the entire comprehension passage to get the overall idea, then work on the individual items. The words remaining around each blank can help you figure what the missing word must be.

There are twenty (20) items. You will have twenty (20) minutes to work on this section.

To record your answers, write the word you think of in the space on the answer sheet. The answer spaces are numbered from 1 to 20 to correspond to the numbers of the blanks in the passage. Try not to leave any questions unanswered. If you can not do one item, go on and come back to it later. The score will simply be the total of correct responses. There is no penalty for guessing, so you should try every item.

If you have any questions, ask them now; if not, wait for the signal to turn the page. Do not start until told to do so.

Part B

Wes Montgomery, Jim Hall, Arelio Diaz, Montaya, Bolesete -- all the great names of the jazz guitar -- have come to the Birds Nest to hear Charlie Byrd, mostly to marvel at his _____1_____. His touch on the frets is so certain and economical that the fingers of his left hand are free of callouses, the _____2_____ of many professional guitarists. His runs are articulated and integral to the _____3_____. He never "runs the changes," or strums through chord progressions while trying to think of another improvisation. His range of musical ideas is so vast that he carries the load of a two-hour program with very little solo help from his accompanists and without repeating himself in mood or even in _____4_____. This is not so remarkable in respect to his classical repertoire, which is derived from scored compositions. But in jazz, the melody instrument must spontaneously and continuously sound interesting. Few if any guitarists have matched Byrd's virtuosity and staying power in this respect. The _____5_____ of Eddie Lang sound halting and thin in comparison, with only a short, brilliant guitar _____6_____ here and there. Django Reinhardt's runs were often more decorative than significant, and his _____7_____ were so repetitious they became monotonous after five or six successive selections. Even the great Charlie Christian tended to repeat once too often some of his spine-tingling flights up and down the strings.

The majority of Byrd's fans today say they "like any music as long as it's good," and Byrd says that, too. But unlike many academic musicians who say that but prove by their jazz performances that they really understand only legitimate music, Byrd can play any kind of music and make it good. Unlike some jazz musicians who claim "there is really no difference between good music and jazz," Byrd insists on playing each in its own fashion. He refuses to "swing the _____8_____," to insert operatic passages in swing numbers, or to build a superstructure of Debussy _____9_____ on top of primitive blues. A typical Byrd set includes transcriptions from Mozart's "Majic Flute," "Desafinado," a popular bossa nova song, and "Big Butter and Egg Man," a 35-year-old jazz standard. The 30-odd record albums Byrd has made include "An Anthology of Guitar Music from the Sixteenth Century," "Brazilian Byrd" and "Jazz at the Showboat." Byrd plays everything as purely as he can according to its own criteria, as he interprets them. His _____10_____ doubtless impresses some of his fans who know more about human nature than they do about music for example, Vice President Humphrey, Secretary of Interior Udall, Former Postmaster General Day, Perle Mesta, Lady Bird and President Lyndon Johnson.

Byrd first met and played for the President, while Mr. Johnson was still a senator. He now holds a Presidential ______11______ for his artistic contribution to the Great Society. He met Mrs. Johnson in 1956, when they both appeared on the same television show and it was she who asked him to perform at the White House last year. "My name helped her remember me," Byrd says in his soft Virginia drawl. He is not related to the late senator from his native state, Harry Flood Byrd although he is a registered Democrat.

In the generally insecure world of the professional musician, Charlie Byrd has it made. He and his wife Ginny, a ______12______ he describes as "a Sophia Loren type," live with their two children in a four-story colonial-style house on Barney Street. They own two cars -- a Mercedes-Benz 220 and a ______13______ station wagon. They have taken sailing lessons with Archie Mason in Annapolis. Byrd's music is broadcast on the Voice of America, as a result, he receives fan mail from behind the Iron Curtain, and has organized fan clubs in Germany, England and South America (although none that he knows of in Washington). The ______14______ price for his trio, which recently changed its incorporated name from Jazz Recital, Inc., to Charlie Byrd, Inc., is $2,500. He is in demand as a cultural ______15______ at embassies, and at places like the Phillips and National Art Galleries, Johns Hopkins and the University of ______16______. He teaches guitar once a week at American University, composes music for theater (Arena Stage Productions, and for Tennessee Williams' "The Purification") and television (for a study of Puerto Ricans on "David Brinkley's Journal"). He has traveled in South America under the auspices of the United States Information Agency, played with a Woody Herman group in Europe and Saudi Arabia, and at the Monterrey Jazz Festival.

He can afford to pick ______17______ on the road to suit his convenience ("We don't do any one-night stands"), he says. He has time to fish (he caught a marlin off Rehoboth recently), time for hobbies (furniture making in the past, reading and sailing now), time to make a social life among doctors, lawyers and others outside the music business, and time to be with his children -- Jeffrey, 13 and ______18______, 11.

In addition to this successful "regular" life -- or in spite of it, according to the criteria of the nomadic jazz musicians of yesteryear -- Byrd won the 1965 Playboy magazine all-star jazz ______19______ as "best jazz guitarist." In 1959, he was chosen by ______20______, the musicians' trade paper, as the best guitarist in the "new star" division of an international jazz critics' poll. In 1963, he was voted best guitarist in the Downbeat readers' poll.

APPENDIX D

Comprehension Test for Passage C

The Cloze Test

Directions

This test consists of the passage you have just heard. At various points in the passage, single words have been left out and replaced by numbered blanks. Your task is to fill in each blank with the same word that was taken out.

It generally helps if you will look quickly over the entire comprehension passage to get the overall idea, then work on the individual items. The words remaining around each blank can help you figure what the missing word must be.

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If you have any questions, ask them now; if not, wait for the signal to turn the page. Do not start until told to do so.

Part C

Charlie Byrd's _______1_______ guitar (a $1,000 nylon-stringed instrument made in Europe by Ignazio Fleta), which Byrd plucks with his bare fingers, without picks, is naturally a more subdued instrument than most any other instrument. He cannot compete with social chatter and glass clinking. He usually plays with his guitar amplified only slightly by a mechanical system which he invented. Unlike most guitar amplification systems, Byrd's is not built into the instrument and it does not harshen its beautifully mellow tone. He plays solo or accompanied discreetly by the rest of the Charlie Byrd Trio -- his younger brother, Peabody Conservatory-trained Eugene (Joe) Byrd on bass violin, and Billy Reichenback on _______2_______.

The guitar in Charlie Byrd's hands, is both a _______3_______ instrument and a melody instrument is ensemble, and Joe Byrd and Reichenbach play behind him so that his every nuance may be appreciated by anyone who wants to listen. Nowdays, the "greatest audience in the world" does want to listen. The polite _______4_______ of Charlie Byrd audiences has become a tribute to his talent that is as gratifying to him as a musician as his triumphs in national magazine polls and his command performance at the White House.

Some hushed praise is to be expected from his latter-day fans. In recent years Byrd has attracted much of the tame, civilized music public in _______5_______ and elsewhere, by playing a great deal of classical and popular music, in addition to the jazz that first established his reputation. He insists on "balanced programming" to please all types of music lovers, some of whom are naturally quiet. Byrd is attended, especially at his college and music-hall concerts, by many "_______6_______" who are attracted by his legitimate repertoire and, in many cases, by the fact that he studied with Andres Segovia. In Byrd's presence, they preserve the traditional cathedral calm they affect in the presence of all Great Music. More and more, too, Byrd draws popular-music addicts who "love that bossa nova and that _______7_______" but who prefer to listen rather than dance to their favorite sounds. If he played nothing but popular music, these followers would probably talk over it, for they are accustomed to treat music as background noise.

But they have learned that Byrd also plays serious music for people who insist on paying strict attention to it, so they keep their mouths shut at the Birds Nest. The pop fans may be "_______8_______," but they are well-mannered by and large. They wait until Mr. Byrd is offstage and ask him for his autograph, even as Luci and Lynda Johnson did when he played at the party their mother gave for them at the White House in March, 1964. Byrd, a well-mannered _______9_______, signs whatever is handed to him.

The original Byrd enthusiasts, however, are jazz fans, a group not noted for sedate behavior, and their silent ____10____ earlier at the Showboat and now at the Birds Nest is something of a global phenomenon. The "hot" jazz fans, or "moldy figs," love Byrd's work for esoteric reasons -- some of which Byrd himself is only obliquely aware of, even though he is more learned about jazz ____11____ than most musicians. The afficionados of hot jazz admire his ability to play blues "in a class with Lonnie Johnson" and other early ____12____ masters, known mainly to specialists. They revel in his skill at driving an ensemble on an unorthodox lead instrument, much as the late obscure Frank Teschmacher led and drove the Chicago Rhythm Kings with a ____13____, then not considered a lead instrument. They adore Byrd's very rare ability to swing in the seldom heard, fragile-forceful manner of the late Jelly Roll Morton's Red Hot ____14____. They are ecstatic about his taste for "standards" from the Golden Age, the songs that were first made famous by Louis Armstrong, Bessie ____15____, and others at about the time, 1925, when Charlie Byrd was born.

Aside from a few elderly, comparatively limited blues pickers, who have been resurrected by the ____16____ music revival, Byrd is one of the very few guitarists around that the hot fans will accept.

Byrd also brings in the less demanding but more numerous semi-square devotees of "____17____," the commercialized fabrication of ancient New Orleans-style jazz, and many fans of modern jazz ("cool" jazz, "progressive," "bop," "Mainstream," etc.). The latter, whose ranks include some of the most demanding, not to say intolerant, critics in the history of music, form the smallest segment in the circle of Byrd's fans. Moderns who believe that guitar jazz began around 1940 when Benny Goodman's guitarist, the late Charlie Christian, turned from ____18____ to bop, are annoyed that Byrd even fools with "ricky-ticky" hot music. The cool bugs know that Byrd has more than enough technique to play the impressionistic harmonies, polytonalities and cross rhythms of modern jazz, but some tend to resent the fact that he embraces such progress for the most part through bossa nova, which is a ____19____ offshoot of modern jazz but is not very "hip." Some of the progressives dislike Byrd's hesitancy, not to say absolute refusal, to attempt to compound legitimate music and jazz into "third stream" music, which is neither fish nor fowl but is lately THE THING in the more academic modern-jazz ____20____.

APPENDIX E

Brief descriptions of the tests from the Guilford experimental battery used in this study.

1. Class Name Selection. S must choose the class name that best represents a set of words or objects from alternatives.

2. Best Trend Name. S must select the word that best describes the order of 4 given words.

3. Word Systems. S must evaluate the internal consistency of a matrix of words arranged in terms of 3 meaningful rows and columns.

4. Sentensence. S must evaluate the internal consistency of the ideas or events expressed in each sentence.

5. Double Descriptions. S must evaluate objects according to how they meet 2 standard criteria in the form of attributes.

6. Verbal Analogies. S must discover the relationship between 2 words and select the word that completes a similar analogy.

7. Best Word Class. S must choose the class name that best represents a given word or object.

8. Unlikely things. S must select from 4 given alternatives the 2 more unlikely things in sketches of a common situation.

9. Word Group Naming. S is required to find a classifying name for a group of words.

10. Picture Group Naming. S must think of the best name which classifies a group of pictures.

11. Inventive Opposites. S must think of 2 words opposite in meaning to a test word. S' words must begin with specified letters.

12. Associations. S is given pairs of words and must think of a single word that has a meaning similar to each of the given words of the pair.

13. Temporal Ordering. S is given a series of steps involved in carrying out a task and must decide on the proper sequence of the steps.

14. Picture Arrangement. S is given four pictures of a comic strip in scrambled order and is required to put them in correct temporal order.

15. Word Grouping. S is presented with a list of approximately a dozen common words and must classify them in a specified number of classes.

16. Group Classification. S is presented with 2 target groups of 4 words and 8 additional groups of 4 words. He must classify the 8 groups into 2 classes, 4 groups per class, so that one of the target groups belongs to one class and the other target group belongs to the second class.

17. Recalled Words. S must list words that are presented on a study page.

18. Picture Memory. S must list names of familiar pictured objects that are presented on a study page.

19. Remembered Relations. S is presented with stimulus sentences, each of which relates 2 units. S must remember the relation between units and then, from relationships given on the test page, choose one that correctly connects 2 elements on the study page.

20. Recalled Analogies. A structured-recall test in which S must complete previously studies, incomplete verbal analogies.

21. Memory for Events. S must remember the order in which a series of events occurred on a study page and decide which of 2 events occurred earlier on the test page.

22. Classified Information. A 2-choice recognition test in which S must choose test-page classes that are similar to classes presented on the study page.

23. Picture Class Memory. S must choose test-page classes that are similar to classes presented on the study page.